Chapter 3: Building Envelope

3.0 CHAPTER OVERVIEW

This chapter discusses the requirements of the *Energy Efficiency Standards* as they apply to the building envelope (walls, roofs, floors, windows, skylights, etc.). It addresses questions a building envelope designer, plan checker or inspector needs answered. Additional information is found in Chapter 2: Scope and Application and Chapter 6: Special Topics.

Chapter Contents

The Introduction section (3.1) explains the basic envelope compliance approaches and provides a tutorial on many of the concepts necessary to an understanding of the envelope requirements. The Envelope Design Procedures section (3.2) discusses the requirements of the *Standards* as they concern a designer. The Envelope Plan Check Documents section (3.3) explains the compliance forms and the information, which must be included on the plans by the designer prior to being checked by the building department.

3.1 INTRODUCTION

The design of the building envelope is generally within the domain of an architect, although it may be done by a contractor, an engineer, or some other person. The designer is responsible for making sure that the envelope design complies with the *Standards*. Likewise, the building department is responsible for making sure that the envelope is designed and built in conformance with the *Standards*. This chapter is addressed to both the designer and the building department, and to the related specialists who participate in the design and construction of the building envelope.

3.1.1 Envelope Compliance Approaches

The envelope requirements contain more than one approach to compliance in order to allow flexibility to accommodate the wide variety of nonresidential buildings. The characteristics, advantages and disadvantages of each method are introduced in this Section. These requirements are in addition to the envelope mandatory measures, which apply regardless of the compliance approach (Section 3.2.1).

A. Prescriptive Approach (§143)

Envelope Component Approach vs. Overall Envelope Approach

Under the prescriptive approach there are two alternatives for envelope compliance: the Envelope Component Approach and the Overall Envelope Approach.

Envelope Component Approach (Section 143(a)) is the simpler and more direct of the two prescriptive compliance approaches. It consists of a specific requirement for each envelope component: roofs and ceilings, exterior walls, demising walls, external floors and soffits, windows, and skylights.

There are no trade-offs between components. If all the requirements are met, the envelope complies. If even one component does not meet its individual requirement, the envelope does not comply.

Under the Envelope Component Approach, each opaque assembly has to meet a minimum insulation level. Each glazing component has to meet insulating and solar heat gain coefficient (SHGC) values, and there is an upper limit on glazing area. If these requirements are met, the building will comply with the *Standards.* See Section 3.2.2 for a more complete discussion of the Envelope Component Approach.

Overall Envelope Approach (Section 143(b)) treats envelope components as a group. This offers the ability to make trade-offs between envelope components, which is the principal advantage of this approach.

The Overall Envelope Approach uses two measures of envelope performance: the overall heat loss and the overall heat gain. The overall heat loss is a measure of the insulating quality of all the envelope components together, including both opaque and glazing surfaces. The overall heat gain is a measure of the insulation quality of the envelope component and the solar heat gain qualities of the glazing and envelope.

The *Standards* for both heat gain and heat loss of the envelope are calculated using the insulation and solar heat gain coefficient values from the Envelope Component Approach, and applying them to the building's envelope surface areas, as designed (with some limits on glazing area). The proposed design's overall heat loss and heat gain are calculated based on the installed insulation and glazing performance. If the proposed heat loss and heat gain are no higher than the standard heat loss and heat gain, then the envelope complies. See Section 3.2.3 for a more complete discussion of the Overall Envelope Approach.

B. Performance Approach (§141)

The other option for envelope compliance is the Performance Approach. It may be used for either envelope-only compliance or may include lighting and mechanical system compliance if permitted at the same time. When the performance approach is used for the envelope only, the computer model deals with the energy efficiency of the entire envelope under both heating and cooling conditions. This means that trade-offs can be made between all envelope components. The computer analysis is much more sophisticated and can account for more subtle energy effects due to surface orientation and hourly changes in the outside temperature. If the envelope compliance is combined with other parts of the building, then more trade-offs can be made, such as increasing envelope efficiency in order to allow more lighting power or a less efficient mechanical system. See Sections 3.2.4 and 6.1 for a more complete discussion of the performance approach.

3.1.2 Basic Envelope Concepts

In order to understand the particulars of each of these approaches, several key definitions and energy concepts must be presented. In addition, before proceeding to the discussion below, the reader should be familiar with the various conditioned space definitions (see Section 2.1.2A).

A. Definitions (§101(b))

Atrium *is an opening through two or more floor levels other than enclosed stairways, elevators, hoistways, escalators, plumbing, electrical, air-conditioning, or other equipment which is enclosed space and not defined as a mall.* The definition of an atrium is significant because of the skylight area requirements. The key concept is that the atrium is an opening through floor levels, not counting openings needed for equipment. Malls are not considered as atria. The skylight requirements are different when the atrium is over 55 feet high. According to the UBC, an atrium over 55 feet high must have a mechanical ventilation system (particulars defined in the UBC), so the higher skylight allowances for atriums only apply when the ventilation system is required. In questionable cases, the determination of atrium height will be made by the building department, and will follow UBC guidelines.

Demising Partitions *are barriers that separate conditioned space from enclosed unconditioned space.* The only difference between an exterior partition and a demising partition is that the demising partition has enclosed unconditioned space on one side, rather than outdoor space. The demising partition could adjoin, for example, an unconditioned warehouse, an enclosed garage, or an unconditioned vestibule. The distinction between exterior and demising walls is made because demising walls have their own requirements and they are not treated the same way as exterior partitions in the energy calculations.

Demising Wall *is a wall that is a demising partition.* A wall is the only case where a demising partition is treated differently from an exterior partition (there are special insulation requirements (Sections 143(a)3 and 118(e)). Glazing area in demising walls is not limited (Sections 141(a) and 143(a)5A).

Display Perimeter *is the length of an exterior wall in a* B, F-1 or M *occupancy that immediately abuts a public sidewalk, measured at the sidewalk level for each story that abuts a public sidewalk.* This generally refers to retail display windows, although other occupancies such as offices can also have a display perimeter. Public sidewalks are accessible to public at large (no obstructions, limits to access, or intervening non-public spaces). The display perimeter is used for a special calculation of window area (Section 143(a)5A). Demising walls are not counted as part of the display perimeter.

Effective Apperture (See Chapter 5).

Exterior Door *is a door through an exterior partition.* The exterior door area is used only in calculating the gross exterior wall area; there are no R-value, U-value or area requirements for exterior doors (Section 143(a)7). Note that if the door has glazing in excess of one-half of the door area, that glazing is a window or a skylight (depending on slope). See discussion of **Window Area** below for the measurement of glazing area in doors.

Exterior Floor/Soffit *is a horizontal exterior partition, or a horizontal demising partition, under conditioned space.* It is measured using exterior dimensions. Note that the conditioned space can be directly or indirectly conditioned space, and it can adjoin either ambient air or enclosed, unconditioned space. Also note that, unlike the residential *Standards,* slabs-on-grade are not considered exterior floors because they do not separate conditioned space from ambient air or unconditioned space (see discussion of **Exterior Partition** below). A floor over a ventilated crawl space or a parking garage would be an exterior floor. Likewise, in a conditioned attic space, the soffit of an overhanging eave would be considered an exterior floor/soffit because it has unconditioned space below (see Figure 3-1).

Exterior Partition *is an opaque, translucent, or transparent solid barrier that separates conditioned space from ambient air or space that is not enclosed. It separates conditioned space (including* **Indirectly Conditioned Space**, as discussed in Section 2.1.2A) from the outdoors or from spaces that are not enclosed. The terms *partition* and *barrier* are used as generic descriptors of any envelope element, including windows, soffits, skylights, metal doors, walls, roofs, etc.

Exterior Roof/Ceiling *is an exterior partition, or a demising partition, that has a slope less than 60 degrees from horizontal, that has conditioned space below, and that is not an exterior door or skylight.* This means that the space above the roof or ceiling can be either ambient air or enclosed, unconditioned space. In either case, the envelope requirements for roofs/ceilings apply. An example of an enclosed, unconditioned space would be a ventilated attic or mechanical room. Another would be the ceiling of a conditioned office built within a taller, unconditioned warehouse space (see Figure 3-2).

Exterior Wall *is any wall or element of a wall, or any member or group of members, which defines the exterior boundaries or courts of a building and which has a slope of 60 degrees or greater with the horizontal plane. An exterior wall or partition is not an exterior floor/soffit, exterior door, exterior roof/ceiling, window, skylight, or demising wall.* This leaves only the opaque wall surfaces defined as exterior walls. They separate directly or indirectly conditioned space from the outdoors. Note that they do not include demising walls, which adjoin enclosed unconditioned space.

Exterior Wall Area *is the area of the opaque exterior surface of exterior walls.* It is measured using exterior dimensions. This area does not include windows or doors.

Fenestration or Glazing Product (same definition) *is any transparent or translucent material plus any sash, frame, mullions and dividers, in the envelope of a building, including, but not limited to: windows, sliding glass doors, french doors, skylights, curtain walls, garden windows, and other doors with a glazed area of more than one-half of the door area.*

Figure 3-1: Requirements for Floor/Soffit Surfaces

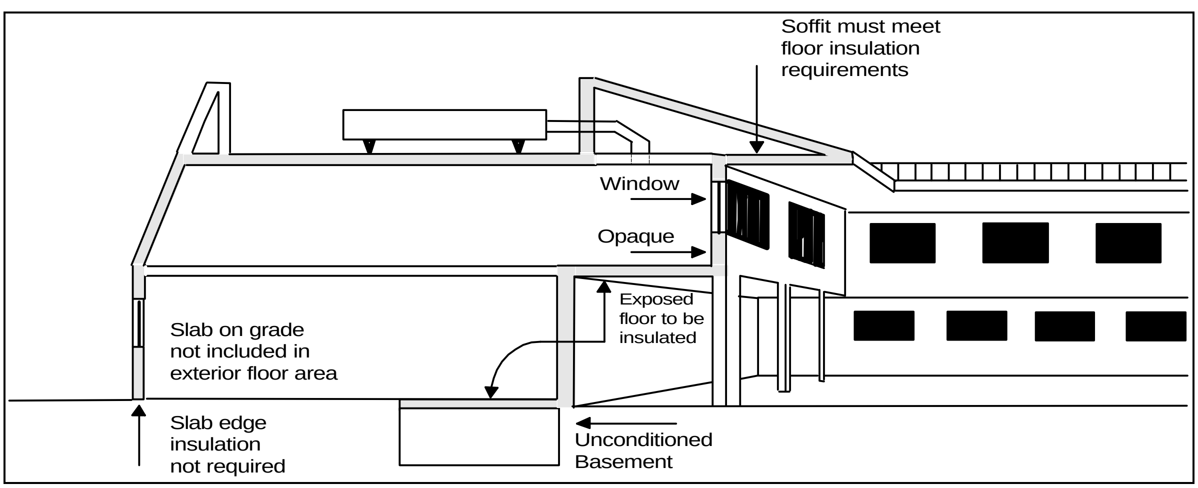
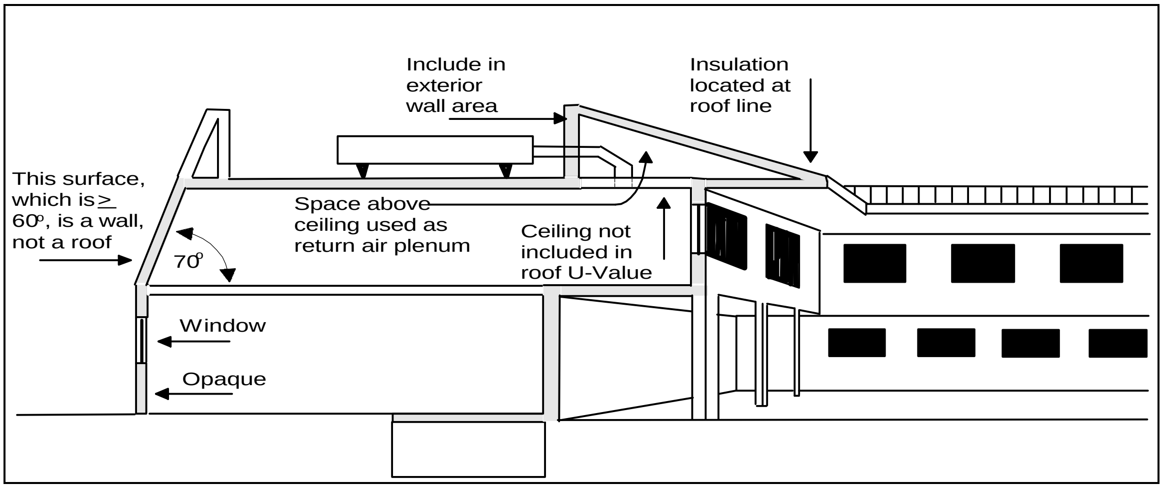


Figure 3-2: Requirements for Roof/Ceiling Surfaces



Field-Fabricated Fenestration Product or Exterior Door *is a fenestration product or exterior door whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product or exterior door.* This type of product does not need to be labeled. *Field fabricated does not include site assembled frame components that were manufactured elsewhere with the intention of being assembled on site (such as knocked down products, sunspace kits and curtainwalls).* The U-value and solar heat gain coefficient are determined from the default table (see Tables 3-10 and 3-11).

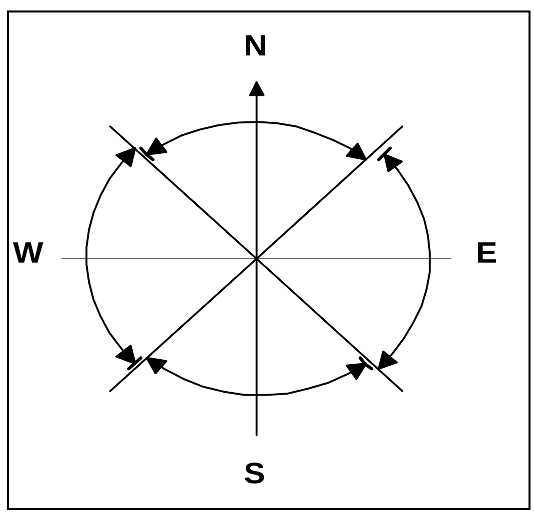
Floor/Soffit Type *is a floor/soffit assembly having a specific heat capacity, framing type, and U-value.*

Gross Exterior Roof Area *is the sum of the skylight area and the exterior roof/ceiling area.* Note that this does not include exterior door areas, such as roof hatches. Roof areas are measured using outside dimensions.

Gross Exterior Wall Area *is the sum of the window area, door area, and exterior wall area.* This area is only used to calculate limits on exterior window area.

Orientation (North, East, South and West) *see Glossary (Appendix G) definitions of* ***North-facing, East-facing, etc.*** The *Standards* make this distinction because solar heat gain differs by orientation, causing the energy flows at the envelope to vary with orientation. In general, any orientation within 45° of true north, east, south or west will be assigned to that orientation. The orientation can be determined from an accurate site plan. Figure 3-3 indicates how surface orientations are determined and what to do if the surface is oriented exactly at 45° of a cardinal orientation. For example, an *east-facing* surface cannot face exactly northeast, but it can face exactly southeast. If the surface were facing exactly northeast, it would be considered north-facing.

Figure 3-3: Surface Orientations

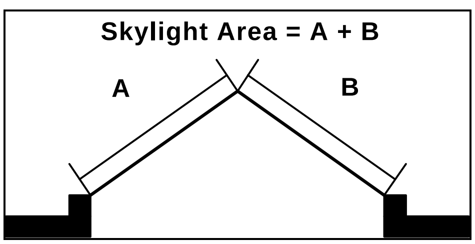


Relative Solar Heat Gain is the ratio of solar heat gain through a fenestration product (corrected for external shading) to the incident solar radiation. solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted or convected into the space.

Skylight *is glazing having a slope less than 60 degrees from the horizontal with conditioned space below, except for the purposes of complying with Standards* Section 151(f) in residential buildings. See discussion of **Slope** below.

Skylight Area *is the area of the surface of a skylight, plus the area of the frame, sash, and mullions.* Since skylights are often not planar, skylight area measurement varies from that for windows. If the skylight is a pyramid, barrel vault or other three-dimensional shape, its surface area is measured across the actual surfaces, not across the flat plane of the opening (see Figure 3-4). The only exception to this is when calculating the skylight-to-roof ratio to determine daylit area under skylights; in that case, the skylight area is the rough opening dimension (see Section 5.2.1C).

Figure 3-4: Skylight Area

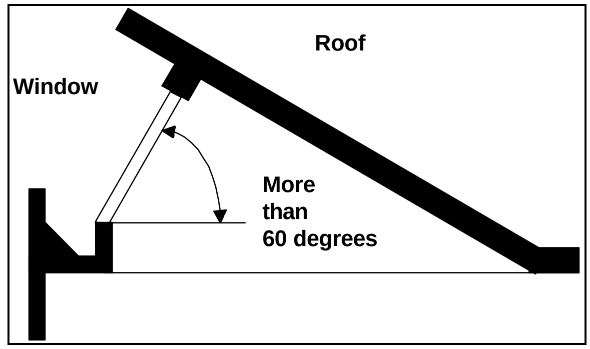


Skylight Type is a skylight assembly having a specific solar heat gain coefficient, whether translucent or transparent, and U-value.

Slope is used to distinguish between walls and roofs (see **Exterior Roof/Ceiling** definition above). If an exterior partition has a slope of less than 60° from horizontal, it is considered a roof; a slope of 60° or more is a wall (see Figure 3-5). This definition extends to fenestration products, including the windows in walls and any skylights in roofs.

Solar Heat Gain Coefficient (SHGC) is the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.

Figure 3-5: Slope of a Wall or Window (Roof or Skylight slope is less than 60°)



Solar Heat Gain Coefficient (SHGC) is the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.

Wall Type is a wall assembly having a specific heat capacity, framing type, and U-value.

Well Index (see Section 5.2.1C)

Window *is glazing that is not a skylight.* Note that the window includes any sash, framing, mullions or dividers.

Window Area *is the area of the surface of a window, plus the area of the frame, sash, and mullions.* As a practical matter, window area is generally taken from the rough opening dimensions. To the extent this opening is slightly larger than the frame, the rough opening area will be a bit larger than the formally defined window area. Use the rough opening area, except for a window in a door. In this case, use the area of the frame that holds the glazing material. For unframed glass doors, use the rough opening of the entire door. If the window is not planar, as with a protruding garden window, then the entire surface area of the fenestration product is used (see **Skylight Area**).

Window Type is a window assembly having a specific solar heat gain coefficient, relative solar heat gain, and U-value.

Window Wall Ratio *is the ratio of the window area to the gross exterior wall area.* Calculate the window area from the rough opening dimensions and divide by the gross exterior wall area, which does not include demising walls. Glazing area in demising walls has no limit and any glazing in demising walls is not counted as part of the exterior wall/window ratio.

B. Insulation R-value (§143(a))

Thermal Resistance (R) *is the resistance of a material or building component to the passage of heat in (hr x ft^2 x °F)/Btu.*

The R-value of an insulation material is a measure of its thermal resistance. The higher the R-value, the greater the thermal resistance or the better the insulating value of the material. The thicker the material, the greater its R-value. R-values are used in the Envelope Component Method as minimum efficiency requirements. They are also used as part of the calculation of the U-values of opaque building envelope assemblies. See the following Sections (C through F) on U-values for more information on these calculations.

Most types of insulating material used in California must be certified by its manufacturer as meeting the California Quality Standards for Insulating Material. See Section 118 for a more complete description of these requirements.

C. Overall Assembly U-value (§143(b))

U-value *is the overall coefficient of thermal transmittance of a construction assembly in Btu/(hr x ft^2 x °F), including air film resistance at both surfaces.*

The U-value describes the rate of heat flow through a building surface. The *Standards* specify U-value limits which translate into minimum insulation requirements for the envelope (see Tables 3-20 and 3-21). The U-value tells how many Btu (British thermal units) of heat energy will pass through one square foot of surface area in an hour, for every degree of difference, between inside and outside air temperature. The higher the temperature difference, the more heat will flow. It follows, then, that lower U-values mean smaller quantities of heat flow, less winter heat loss and less summer heat gain. U-values are always calculated to three significant digits.

The U-value calculation varies depending on the composition of the wall, roof, or other assembly under consideration. The variations are discussed in the following sections.

In addition to the insulating properties of the materials that make up a construction assembly, such as a wall, thin layers of still air cling to the surface of the assembly. These air films, as they are called, add to the insulating value of the assembly. They are accounted for in the U-value, and can have a significant effect on envelope compliance, especially for uninsulated assemblies.

In U-value calculations, there are standard air film R-values that are used for compliance purposes (see the following subsections for discussion of U-value calculations). The standard values assume that the interior air film is in still air, and that the exterior air film is in a 15 mile per hour breeze, which considerably reduces its insulating value. Table 3-1 lists the standard air film R-values.

The following subsections describe how the U-values of various envelope components are calculated. These U-values are used to demonstrate compliance with the envelope *Standards*.

> NOTE:
>
> Weight averaging of assemblies requires a U-value. R-values cannot be weight averaged.

D. Wood Frame U-values (§141(c)4.B)

Framed Partition or Assembly *is a partition or assembly constructed using separate structural members spaced not more than 32 inches on center.*

Wood-framed assemblies are common in smaller nonresidential buildings, and are known by such names as stud walls, roof rafters and floor joists.

They use small dimension lumber as the structural elements, typically spaced on 16 inch or 24 inch centers. The cavities between the framing members typically are filled with insulation.

Table 3-1: Standard Air Film R-values

AIR FILMS [1]				
	Wall	**Roof**		**Floor**
		Flat [2]	45° Angle	
Inside	0.68	0.61	0.62	0.92
Outside	0.17	0.17	0.17	0.17
AIR SPACES [4]				
0.5 inch	0.77	0.73	0.86	0.77
0.75 inch	0.84	0.75	0.81	0.85
1.5 inch	0.87	0.77	0.80	0.94
3.5 inch [5]	0.85	0.80	0.82	1.00

NOTE: Values from ASHRAE Handbook of Fundamentals, 1993 edition, Chapter 22, Tables 1 & 2.

[1] Assumes a non-reflective surface emittance of 0.90 and winter heat flow direction.
[2] Use the "Flat" roof R-values for roof angles between horizontal and 22 degrees.
[3] Use the 45 degree roof R-values for roof angles between 23 and 60 degrees.
[4] Assumes mean temperature of 90 degrees Fahrenheit, temperature difference of 10 degrees Fahrenheit, surface emittance of 0.82 and winter heat flow direction.
[5] Use these R-values for air spaces greater than or equal to 3-2 inches, such as attics.

Any time a typical wood-frame assembly is used, the U-values listed in Table B-2 (see Appendix B) can be used (a portion of Table B-2 is included as Table 3-2). Table B-2 provides a wide range of typical wood-framed assemblies.

To use Table B-2, identify the appropriate type and spacing of the framing. Next, locate the R-value of the cavity insulation. Finally, use the R-value of the layer of insulated sheathing (such as rigid foam insulation board) attached to the assembly and select the row of the table showing the U-value of the assembly. Use the "zero" R-value if there is no insulated sheathing. Note that *insulated sheathing* does not include ordinary building materials such as plywood or stucco; it is rigid board material designed to be used as insulation. Examples of this type of insulation are polystyrene and polyisocyanurate. These default U-values must be used for compliance purposes, unless calculations are submitted for each assembly.

Likewise, if the assembly is not included in the table, or if the assembly is a framed floor, ceiling, or soffit, the U-value must be calculated using the parallel path method, in which case the applicant must submit calculations using ENV-3 (see Section 3.3.6).

Table 3-2: Wood Framed Assembly U-values (excerpt from Table B-2, Appendix B)

Framing Type and Spacing	Framing Cavity R-Value	Insulated Sheathing R-Value	Wood Wall U-Value
2x4 @ 16" O.C.	11	0	0.098
	(compressed)	4	0.068
		5	0.064
		7	0.056
		8.7	0.051
	13	0	0.088
		4	0.063
		5	0.059
		7	0.052
		8.7	0.048
	15	0	0.081

Parallel Path Method. Wood framed assembly U-values are calculated using the parallel path method (see ENV-3 Wood Framed Assembly). This method takes account of the fact that heat flows at a different rate through the solid wood framing portion of the surface than through the insulated cavity portion. The U-value developed by the method is essentially an area-weighted average of the U-values of the frame and cavity areas. The parallel path method is described in the *ASHRAE Handbook, 1993, Fundamentals Volume*, Chapter 22 (see Appendix B). For compliance purposes, the parallel path method calculation is done for each wood-framed assembly using the ENV-3 form. Refer to Section 3.3.6 for a step-by-step explanation of this calculation and the form.

Because the parallel path method weights the U-values of the framing and the cavity areas, a key number in the calculation is the *framing percent* *age.* This number describes the percentage of the surface area that is occupied by framing; the rest is occupied by cavity and insulation. In order to simplify the calculation and to avoid confusion, the Energy Commission has adopted common framing percentages, found below in Table 3-3.

Table 3-3: Wood Framing Percentage

Assembly Type	Framing Spacing	Framing Percentage
Walls	16" o.c. 24" o.c.	15% 12%
Floors	16" o.c. 24" o.c.	10% 7%
Roofs	16" o.c. 24" o.c.	10% 7%
1993 ASHRAE Handbook of Fundamentals, Chapter 22		

E. Metal Frame U-values (§141(c)4.C)

Framed Partition or Assembly *is a partition or assembly constructed using separate structural members spaced not more than 32 inches on center.* Metal framing, typically using steel studs, rafters or joists made of rolled shapes of light gauge steel, is common in non-combustible construction. The framing techniques are similar to those for wood framing; small dimension structural members are typically placed on 16 inch or 24 inch centers, and the cavities between the framing members are filled with insulation. This method does not apply when the framing spacing is 32 inches or more.

Metal-framed assemblies have greater heat transfer than wood-framed assemblies, of similar construction. This is because the steel material is an effective heat conductor. Heat flows rapidly through the framing members, bypassing the cavity insulation. The net result is substantial reduction in the effectiveness of the insulation.

To account for this effect, the zone method is used for determining the U-value of a metal-framed assembly instead of the parallel path method. This method is described in the *ASHRAE Handbook, 1993, Fundamentals Volume*, Chapter 22 (see Appendix B). A hand calculation using the zone method is elaborate, and is not recommended for use without training.

Other alternatives to performing zone method calculations include the use of ENV-3 for Metal Framed Assemblies, default table (Table 3-4), and a computer program were developed by the Energy Commission to determine the U-values of construction assemblies, including those with metal framing (see Appendix B).

Table 3-4 is an excerpt from Table B-2, the Wall Assembly U-value Table found in Appendix B, which provides U-values for a wide range of typical metal-framed wall assemblies. They were calculated using the zone method. These values may be used for compliance purposes, unless the applicant submits calculations for each assembly separately (using form ENV-3 Metal Frame; see Section 3.3.4). Interpolating or extrapolating values in this table is prohibited.

To use this table, identify the appropriate type and spacing of the framing. Next, locate the R-value of the cavity insulation. Finally, use the R-value of the layer of insulated sheathing attached to the assembly and select the row of the table showing the U-value of the assembly. Use “zero” R-value if there is no insulated sheathing.

Table 3-4: Metal Framed Assembly U-values (excerpt from Table B-2)

Framed Wall Assembly U-Values			
Framing Type and Spacing	Framing Cavity R-Value	Insulated Sheathing R-Value	Metal Wall U-Value
2x4 @ 16" o.c.	R-11	0.0	0.202
		4.0	0.112
		5.0	0.101
		7.0	0.084
		8.7	0.073

Note that *insulated sheathing* does not include ordinary building materials such as plywood or stucco; it is rigid board material designed to be used as insulation. Examples of this type of insulation are polystyrene and polyisocyanurate.

If the value in Table B-2 is not used, or if the assembly is a metal-framed floor, ceiling or soffit, the U-value may be calculated using the metal framing factors found in Table 3-5 (see Appendix B, Table B-3). Using the ENV-3 Metal Framed

Assembly form described more fully in Section 3.3.4, multiply the values in this table by the sum of R-values of all layers including air films, excluding any insulated sheathing. Add the insulated sheathing R-value, if any, to obtain the total assembly R-value. Using this value, calculate the U-value.

Table 3-5: Metal Framing Factors

METAL FRAMING FACTORS*			
Stud Spacing	**Stud Depth**	**Insulation R-Value**	**Framing Factor**
16" o.c.	4"	R-7	0.522
		R-11	0.403
		R-13	0.362
		R-15	0.328
	6"	R-19	0.325
		R-21	0.300
		R-22	0.287
		R-25	0.263
24" o.c.	4"	R-7	0.577
		R-11	0.458
		R-13	0.415
		R-15	0.379
	6"	R-19	0.375
		R-21	0.348
		R-22	0.335
		R-25	0.308
R-value calculation for Exterior Wall Assemblies with Metal Studs, July 19, 1990, Staff Draft Docket 90-CON-1.			
*Correction to metal framing factors applies to the entire assembly including: interior air films, interior surfaces, cavity/insulation, exterior surfaces, and exterior air films.			

F. Masonry U-values (§141(c)4.E)

Masonry wall assemblies are typically built using concrete masonry units (block), or with various clay products (brick or tile). They also include solid masonry or concrete assemblies, such as tilt-up concrete walls. The heat flow across these walls can be complex because of the voids in the wall, the solid material bridges through the wall, and the reinforcing and grouting of some of the voids for structural reasons.

The recommended procedure for determining masonry wall U-values is to use the tables of values provided in this *Manual* in Tables B-4 through B-6 (see Appendix B). Alternatively, it is permissible to use either the method of transverse isothermal planes described in the *ASHRAE Handbook, 1993, Fundamentals Volume*, Chapter 22, or the method described in *Energy Calculations and Data*, published by the Concrete Masonry Association of California and Nevada, 1986.

A simplified version of the latter method was used to develop Table B-4, excerpted in Table 3-6. This table lists various typical hollow unit masonry units by nominal wall thickness (12", 10", etc.), and by material type. For example, NW CMU refers to normal weight concrete masonry units (concrete blocks). The table also provides for the three typical core treatments: solid grout and two types of partially grouted core treatments. The ungrouted cells in partially grouted walls are either empty or filled with perlite insulation. The table gives the U-value for the wall, including interior and exterior air films. It also provides the total R-value and the heat capacity (HC) (see Subsection 3.1.2G for more on heat capacity). The use of these numbers in determining the U-value of complex masonry assemblies is explained in Section 3.3.5 (ENV-3: Proposed Masonry Wall Assembly).

Table 3-6: Properties of Hollow Unit Masonry Walls (excerpt from Table B-4)

Type			Core Treatment		
			Solid Grout	Partly ~~Grouted~~ with Ungrouted Cells: Empty	Filled w/Perlite
12"	LW CMU	U	0.51	0.43	0.30
		Rt	2.0	2.3	3.3
		HC	23.0	14.8	14.8
	MW CMU	U	0.54	0.46	0.33
		Rt	1.9	2.2	3.0
		HC	23.9	15.6	15.6
	NW CMU	U	~~0.57~~	0.49	0.36
		Rt	1.8	2.0	2.8
		HC	24.8	16.5	16.5

Table B-5 is used to find the values for solid masonry assemblies not made up of hollow masonry units (e.g. poured concrete), and is excerpted in Table 3-7.

Table 3-7: Properties of Solid Unit Masonry and Solid Concrete Walls (excerpt from Table B-5)

Type		Layer Thickness, inches 3	4	5	6
LW CMU	U	na	0.71	0.64	na
	Rw	na	1.4	1.6	na
	HC	na	7.00	8.75	na
MW CMU	U	na	0.76	0.70	na
	Rw	na	1.3	1.4	na
	HC	na	7.67	9.58	na
NW CMU	U	0.89	0.82	0.76	na
	Rw	1.1	1.2	1.3	na
	HC	6.25	8.33	10.42	na
Clay Brick	U	0.80	0.72	0.66	na
	Rw	1.3	1.4	1.5	na
	HC	6.30	8.40	10.43	na
Concrete	U	0.96	0.91	0.86	0.82
	Rw	1.0	1.1	1.2	1.2
	HC	7.20	9.60	12.00	14.40

G. Heat Capacity (Tables 3-8 and 3-9)

Heat Capacity (HC) *of an assembly is the amount of heat necessary to raise the temperature of all the components of a unit area in the assembly one degree F. It is calculated as the sum of the average thickness times the density times the specific heat for each component, and is expressed in Btu per square foot per degree F.*

Heat capacity describes the thermal mass of an assembly. It is used in the prescriptive envelope requirements for walls and floors, where the U-value criterion is tied to the heat capacity of the assembly.

Table 3-8: Effective R-Values for Interior Insulation Layers on Structural Mass Walls (excerpt from Table B-6)

Type Actual Thick	Frame	Furring space R-value without framing effects 0	1	2	3	4	5	6	7	8	9	10
Any	None	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10
0.5"	Wood	1.3	1.3	1.9	2.4	2.7	na	na	na	na	na	na
	Metal	0.9	0.9	1.1	1.1	1.2	na	na	na	na	na	na
0.75"	Wood	1.4	1.4	2.1	2.7	3.1	3.5	3.8	na	na	na	na
	Metal	1.0	1.0	1.3	1.4	1.5	1.5	1.6	na	na	na	na
1.0"	Wood	1.3	1.5	2.2	2.9	3.4	3.9	4.3	4.6	4.9	na	na
	Metal	1.0	1.1	1.4	1.6	1.7	1.8	1.8	1.9	1.9	na	na

For a single layer, homogeneous wall or floor, such as poured concrete walls with no applied finish materials, heat capacity can be calculated by multiplying the weight of the wall (pounds per square foot) times the specific heat. For instance, a 6 inch concrete wall (specific heat = 0.20 Btu/lb-°F) with a weight of 70 pounds per square foot would have an HC of 70 x 0.20 or 14 Btu/ft^2-°F. To calculate the wall weight from the density (pounds per cubic foot), multiply the density by the wall thickness (inches) and then divide by 12 (inches) which gives the wall weight in pounds per square foot.

For assemblies made up of many layers, the HC may be calculated separately for each layer and summed. The Proposed Construction Assembly, form ENV-3, includes a procedure for calculating HC in simple layered assemblies (see Section 3.3.6).

Table 3-9 lists the thermal properties of typical, thermally massive construction materials. See Appendix B, Table B-1, for a more thorough listing of the thermal characteristics of materials.

The HC of unit masonry walls, such as those made of concrete block or brick, are too complicated to calculate by this method. Appendix B, Materials Reference includes Tables B-4 and B-5 with HCs calculated for a large variety of masonry wall assemblies. See Section 3.1.2F for an introduction to these tables.

Table 3-9: Thermal Mass Properties

Matter	Conductivity (Btu/hr-ft-oF)	Density (Lbs/cf)	Specific Heat (Btu/lb-oF
Adobe	0.33	120	0.20
Heavy Concrete	0.98	140	0.20
Lightweight Concrete	0.36	85	0.20
Gypsum	0.09	50	0.26
Masonry Veneer	0.62	127	0.20
Masonry Infill	0.44	120	0.20
Concrete Masonry Unit	0.59	105	0.20
Grouted Concrete Masonry Unit	1.00	134	0.20
Stucco	0.47	105	0.20
Tile in Motar	0.67	120	0.20
Solid Wood (fir)	0.07	32	0.33
ASHRAE Handbook of Fundamentals, Table 4, Chapter 22			

H. Fenestration U-values (§141(c)4.D)

The U-value for a fenestration product describes the rate of heat flow through the entire unit, not just the glass or plastic glazing material. The U-value includes the heat flow effects of the glass, the frame, and the edge-of-glass conditions (there may be spacers, sealants and other elements that affect heat conduction).

The Glossary lists many of the new terms and product characteristics to acquaint readers with some of the possibilities.

Manufactured Windows and Skylights. Because of inconsistencies in the methods used by window manufacturers in developing and reporting U-values for their fenestration products, a joint industry/ government effort has been underway to standardize procedures.

Standards Section 116(a)2 requires every installed manufactured window or skylight to display a label indicating its rated U-value and SHGC solar heat gain coefficient.

The manufacturers can obtain U-value and SHGC ratings from the National Fenestration Rating Council's (NFRC) rating procedure, or from the Energy Commission's Default Tables (Tables 3-10 and 3-11).

The NFRC has available a *Certified Products Directory* containing NFRC certified U-values for more than 3800 products. The directory is available by contacting:

NFRC
1300 Spring Street, 5th Floor
Silver Springs, MD 20910
(301) 589-6372

Table 3-10: Default Fenestration Product U-Values

Frame Type[1]	Product Type	Single Pane U-value	Double Pane U-value[2]
Metal	Operable	1.28	0.87
Metal	Fixed	1.19	0.72
Metal	Greenhouse/ Garden Window	2.26	1.40
Metal	Doors	1.25	0.85
Metal	Skylight	1.72	0.94
Metal, Thermal Break	Operable		0.71
Metal, Thermal Break	Fixed		0.60
Metal, Thermal Break	Greenhouse/ Garden window		1.12
Metal, Thermal Break	Doors		0.64
Metal, Thermal Break	Skylight		0.80
Non-Metal	Operable	0.99	0.60
Non-Metal	Fixed	1.04	0.57
Non-Metal	Doors	0.99	0.55
Non-Metal	Greenhouse/ Garden window	1.94	1.06
Non-Metal	Skylight	1.47	0.68

[1] Metal includes any field-fabricated product with metal cladding. Non-metal framed manufactured fenestration products with metal cladding must add 0.04 to the listed U-value. Non-Metal frame types can include metal fasteners, hardware, and door thresholds. Thermal break product design characteristics are:

a. The material used as the thermal break must have a thermal conductivity ≤ 3.6 Btu-inch/hr-ft^2-°F,
b. The thermal break must produce a gap of ≥ 0.210",
c. All metal members of the fenestration product exposed to interior and exterior air must incorporate a thermal break meeting the criteria in (a) and (b) above.

In addition, the fenestration product must be clearly labeled by the manufacturer that it qualifies as a thermally broken product in accord with Section 116.

[2] For all dual glazed fenestration products, adjust the listed U-values as follows:

a. Subtract 0.05 for spacers of 7/16" or wider.
b. Subtract 0.05 for products certified by the manufacturer as low-E glazing.
c. Add 0.05 for products with dividers between panes if spacer is less than 7/16" wide.
d. Add 0.05 to any product with true divided lite (dividers through the panes).

I. Solar Heat Gain Coefficient (§141(c)5)

The SHGC is a measure of the quantity of solar heat entering a window or skylight; the lower the SHGC, the lower the amount of solar heat. A low SHGC reduces solar heat gains, thereby reducing the amount of air conditioning energy needed to maintain comfort levels in the building.

SHGC are reported on the product label by glazing material manufacturers for their products. In cases where the specific glazing product is not known, values from the default Solar Heat Gain Coefficient Table 3-11 are used.

Table 3-11: Default Solar Heat Gain Coefficient

Frame Type	Product	Glazing	Total Window SHGC Single Pane	Total Window SHGC Double Pane
Metal	Operable	Uncoated	0.80	0.70
Metal	Fixed	Uncoated	0.83	0.73
Metal	Operable	Tinted	0.67	0.59
Metal	Fixed	Tinted	0.68	0.60
Metal, Thermal Break	Operable	Uncoated	0.72	0.63
Metal, Thermal Break	Fixed	Uncoated	0.78	0.69
Metal, Thermal Break	Operable	Tinted	0.60	0.53
Metal, Thermal Break	Fixed	Tinted	0.65	0.57
Non- Metal	Operable	Uncoated	0.74	0.65
Non- Metal	Fixed	Uncoated	0.76	0.67
Non- Metal	Operable	Tinted	0.60	0.53
Non- Metal	Fixed	Tinted	0.63	0.55

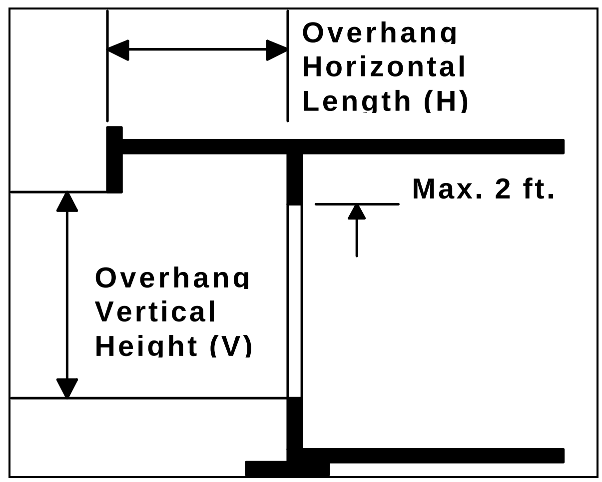
SHGC = Solar Heat Gain Coefficient

Note that, unlike the residential performance compliance procedures, nonresidential windows are not allowed credit for any interior shading such as *draperies* or blinds. Only exterior shading devices permanently attached to the building, or a structural component of the building, can be modeled (i.e. shade screen). Manually operable shading devices cannot be modeled. Overhangs can be credited using the Relative Solar Heat Gain procedure (see 3.1.2J below).

J. Relative Solar Heat Gain §143(a)5.C)

This value is essentially the same as SHGC, except for the external shading correction. It is calculated by multiplying the SHGC of the fenestration product by the overhang factor.

Figure 3-6: Overhand Dimensions



Overhang factor may either be calculated automatically (see Equation 3-1) or may be taken from Table 3-12. The factor depends upon the ratio of the overhang horizontal length (H), and the overhang vertical height (V). These dimensions are measured from the vertical and horizontal planes passing through the bottom edge of the window glazing, as shown in Figure 3-6. An overhang factor may be used *if the overhang extends beyond both sides of the window jamb a distance equal to the overhang projection (Section 143(a)5.C.ii).* The overhang projection is equal to the overhang length (H) as shown in Fig. 3-6. If the overhang is continuous along the side of a building, this restriction will usually be met. If there are overhangs for individual windows, each must be shown to extend far enough to each side of the window.

Equation 3-1: Relative Solar Heat Gain

RSHG = SHGCwin x [1 + aH/V + b(H/V)^2]

Where

RSHG = Relative solar heat gain.

$SHGC_{win}$ = Solar heat gain coefficient of the window.

H = Horizontal projection of the overhang from the surface of the window in feet, but no greater than V.

V = Vertical distance from the window sill to the bottom of the overhang, in feet.

a = -0.41 for North-facing windows, -1.22 for South-facing windows, and -0.92 for East- and West-facing windows.

b = 0.20 for North-facing windows, 0.66 for South-facing windows, and 0.35 for East- and West-facing windows.

Table 3-12: Overhang Factors

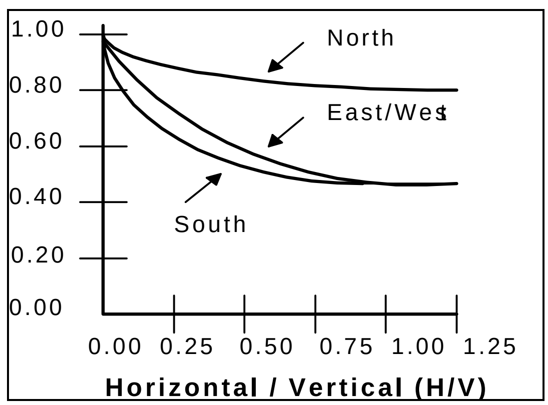
H/V	North	East/West	South
0.00	1.00	1.00	1.00
0.05	0.98	0.95	0.94
0.10	0.96	0.91	0.88
0.15	094	0.87	0.83
0.20	0.93	0.83	0.78
0.25	0.91	0.79	0.74
0.30	0.90	0.76	0.69
0.35	0.88	0.72	0.65
0.40	0.87	0.69	0.62
0.45	0.86	0.66	0.58
0.50	0.85	0.63	0.56
0.55	0.84	0.60	0.53
0.60	0.83	0.57	0.51
0.65	0.82	0.55	0.49
0.70	0.81	0.53	0.47
0.75	0.80	0.51	0.46
0.80	0.80	0.49	0.45
0.85	0.79	0.47	0.44
0.90	0.79	0.46	0.44
0.95	0.79	0.44	0.44
1.00	0.79	0.43	0.44
1.05	0.79	0.43	0.44
1.10	0.79	0.43	0.44
1.15	0.79	0.43	0.44
1.20	0.79	0.43	0.44
1.25	0.79	0.43	0.44

In addition, if the bottom of the overhang (shading cut-off edge) is more than two vertical feet higher than the top of the window (window head), then the overhang does not qualify to receive an overhang factor.

To use Table 3-12, measure the horizontal projection of the overhang (H) and the vertical height from the bottom of the glazing to the shading cut-off point of the overhang (V). Then calculate H/V. Enter the Table at that point. Move across to the column that corresponds to the orientation of the window and find the overhang factor. Note that any value of H/V greater than one has the same overhang factor (for a given orientation).

Figure 3-7 graphs the overhang factors of the various orientation as a function of H/V. It shows that overhangs have only a minor effect on the north (maximum reduction in SHGC is only about 20 percent). East, west and south overhangs can achieve reductions of 55 - 60 percent. The benefits of the overhang level off as the overhang becomes large. (Note: this graph is presented only to illustrate the benefits of overhangs. Do not use the graph to scale values of the overhang factor; use Table 3-12 or calculate the value directly from Equation 3-1.)

Figure 3-7: Graph of Overhang Factors



Example 3-1: RSHG Calculation

Question

An east-facing window has glass with a solar heat gain coefficient of 0.71. It has a fixed overhanging eave that extends three feet out from the plane of the glass (H=3), and which is six feet above the bottom of the glass (V=6). NOTE: the overhang extends more than three feet beyond each side of the glass and the top of the window is less than two feet vertically below the overhang. What is the RSHG for this window?

Answer

First, calculate H/V. This value is 3 / 6 = 0.50. Next, find the overhang factor from Table 3-12. For east-facing windows, this value is 0.63. Finally, multiply it by the solar heat gain coefficient to obtain the RSHG: 0.63 x 0.71 = 0.45 = RSHG.

3.2 ENVELOPE DESIGN PROCEDURES

3.2.1 Mandatory Measures

The mandatory measure requirements apply to new construction, additions and altered envelope components.

A. Doors, Windows and Skylights (§116)

The mandatory measures for doors, windows and skylights affect the air-tightness of the units and how their U-value and SHGC are determined. Fenestration products must be labeled with a U-value and SHGC and the manufacturer or independent certifying organization must certify that the product meets the air infiltration requirements of Section 116(a). Doors and windows must be tested and shown to have infiltration rates not exceeding the values shown in Table 3-13.

For field-fabricated products or an exterior door, the *Standards* require that the unit be caulked, gasketed, weather-stripping or otherwise sealed (Section 116(b)). Unframed glass doors and fire doors are the two exceptions to these requirements.

Where possible, it is best to decide what make and model of fenestration will be used before completing compliance documents. See Section 3.1.2H for information on obtaining the NFRC *Certified Products Directory.*

Table 3-13: Maximum Air Infiltration Rates

	Windows (CFM/sf) of window area	**Residential Doors** (CFM/sf) of door area	**All Other Doors** (CFM/sf) of door area	
Type	All	Swinging, Sliding	Sliding, Swingingg (single door)	Swinging (double door)
Rate	0.3	0.3	0.3	1.0

If the specifier does not know the make and model number of the fenestration products to be installed, there are four options:

- **Look up the U-values and SHGC for a number of similar products in a fenestration directory and use the highest value.** This will help to ensure that whatever product is installed, the U-value and SHGC will not be higher. A building inspection failure will result when a product that is less efficient than specified on the plans is installed.
- **Use the appropriate U-value and SHGC from the Default Fenestration Product table (see Tables 3-10and 3-11).**
- **Use the U-value and SHGC from the Envelope Prescriptive requirements** (Tables 3-20 and 3-21) The plans should also include a note to the buyer that the U-value and SHGC of the product purchased and installed must match or be lower than specified in the compliance documentation.
- **Specify a particular product and state “or equivalent.”** Again, the plans should include a note to the buyer that the U-value and SHGC of the product purchased and installed must

match or be lower than specified in the compliance documentation.

B. Joints and Openings (§117)

The basic requirement of this section is that all joints and other openings in the building envelope that are potential sources of air leakage be caulked, gasketed, weather-stripped, or otherwise sealed to limit air leakage into or out of the building. This applies to penetrations for pipes and conduits, ducts, vents and other openings. It means that all gaps between wall panels, around doors Ceiling joints, lighting fixtures, plumbing openings, doors and windows, and other construction joints must be well sealed.

Ceiling joints, lighting fixtures, plumbing openings, doors and windows should all be considered as potential sources of unnecessary energy loss due to infiltration. No special construction requirements are necessary for suspended (T-bar) ceilings. Standard construction (insulation on ceiling tiles) is adequate for meeting the infiltration/exfiltration requirements.

C. Insulation Materials (§118)

The California Quality Standards for Insulating Materials, which became effective on January 1, 1982, ensure that insulation sold or installed in the state performs according to the stated R-value and meets minimum quality, health, and safety standards.
Manufacturers must certify insulating materials to comply with California Quality Standards for Insulating Materials. Builders may not install the types of insulating materials listed in Table 3-14 unless the product has been certified by the manufacturer. Builders and enforcement agencies should use the Department of Consumer Affairs *Consumer Guide and Directory of Certified Insulation Material* to check compliance. (Note this is not an Energy Commission publication.) If an insulating product is not listed in the most recent edition of the directory, contact the Department of Consumer Affairs, Thermal Insulation Program at (916) 574-2046.

The California Quality Standards for Insulating Materials also require that all exposed installations of faced mineral fiber and mineral aggregate insulations must use fire retardant facings that have been tested and certified not to exceed a flame spread of 25 and a smoke development rating of 450. Insulation facings that do not touch a ceiling, wall, or floor surface, and faced batts on the underside of roofs with an air space between the ceiling and facing are considered exposed applications.

Flame spread ratings and smoke density ratings are shown on the insulation or packaging material or may be obtained from the manufacturer.

D. Demising Walls (§118(e))

Demising walls separating conditioned space from enclosed unconditioned space, must be insulated with a minimum of R-11 insulation if the wall is a framed assembly. This requirement applies to buildings meeting compliance under the prescriptive or performance approach. This requirement assures at least some insulation in a wall where an adjoining space may remain unconditioned indefinitely.

Table 3-14: Certified Insulating Materials

Type	Form
Aluminum foil	reflective foil
Cellular glass	board form
Cellulose fiber	loose fill and spray applied
Mineral aggregate	board form
Mineral fiber	blankets, board form, loose fill
Perlite	loose fill
Phenolic	board form
Polystyrene	board form, molded extruded
Polyurethane	board form and field applied
Polyisocyanurate	board form and field applied
Urea formaldehyde	foam field applied
Vermiculite	loose fill

3.2.2 Prescriptive Envelope Component Approach (§143(a))

The Envelope Component Approach is the simplified approach. Under this approach, each of the envelope assemblies (walls, roofs, floors, windows, skylights) complies individually with its requirement. If one piece of the envelope does not comply, the entire envelope does not comply. The simplicity of this approach means there can be no trade-offs between components. If one or more of the envelope components cannot meet its requirement, the alternative is to use either the Overall Envelope or the Performance Approach, either of which allows trade-offs between components.

Under the Envelope Component Approach, the requirement for each opaque (non-glazing) component takes one of two forms: R-value of its insulation or overall U-value of the assembly. Glazing component requirements address U-value, solar heat gain coefficient, and an upper limit on glazing area. The requirements are found in Tables 3-20 and 3-21 with applicable excerpts in the following sections. The requirements vary by climate zone, occupancy and, in some cases, heat capacity. Compliance is demonstrated on the ENV-2, Envelope Component Method form.

A. Exterior Roofs and Ceilings (§143(a)1)

Exterior roofs or ceilings can meet the component requirements in one of two ways: install the required R-value of insulation, or demonstrate that the overall U-value of the assembly meets the required U-value (Section 141(c)4). If the insulation by itself meets the R-value requirement, then that component complies with this approach. If not, then the U-value calculation allows for the overall insulating qualities of the assembly which also acknowledges the effects of wood or metal framing. For ceilings the effects of T-bar framing and metal lighting fixtures must be included in determining the overall U-value of an assembly.

When recessed lights are not IC-rated, the weighted average ceiling assembly is calculated as two parallel assemblies:

1. The effective R-value of the ceiling assembly is the sum of (a) T-bar/acoustic tile (to account for the metal grids, assume 1/2 the tile's R-value); (b) ceiling insulation; and (c) two inside air film resistances (0.61 R-value per air film).

2. The effective R-value of the light fixtures is calculated as the sum of two inside air film resistances (0.61 R-value per air film). If the fixtures include plastic diffusers, the R-value of the light fixture should be calculated as two air film resistances and a 1.5 inch air space (0.77 R-value).

   NOTE: When fixtures are IC-rated and covered by insulation, the insulation R-value alone may be used to show compliance with the prescriptive requirements or the above calculation can be modified to include the insulation R-value in the light fixture assembly.

The two parallel assemblies are then weight averaged and the U-value calculated.

> NOTE:
>
> You cannot use the EZFRAME program for T-bar/drop ceiling assemblies.

When envelope calculations are prepared before the lighting plan, the following default values may be used to determine the percentage of the ceiling assembly made up of light fixtures:

General Commercial/Industrial:

Work Buildings	10%
Grocery	15%
Industrial/Comm.Storage	7%
Medical Buildings	12%
Office Building	12%
Religious Worship, Auditorium, and Convention Ctr	16%
Restaurants	12%
Retail and Wholesale	16%
Schools	15%
Theaters	12%
All Others	7%

Figure 3-8: Roof/Ceiling Flowchart

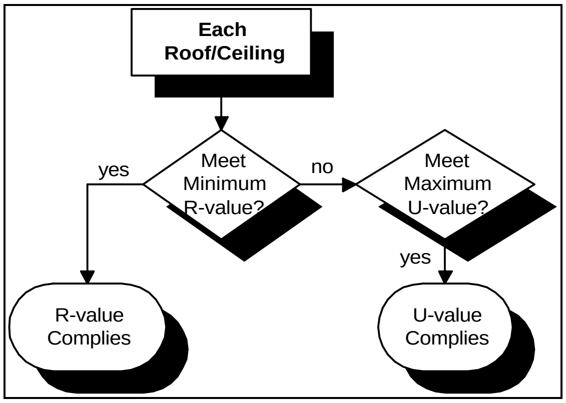


Table 3-15: Roof/Ceiling Requirements

Nonresidential: Roof/Ceiling					
	Climate Zones				
	1,16	2-5	6-10	11-13	14-15
R-value Wood or Metal	**19**	**19**	**11**	**19**	**19**
U-value	0.057	0.057	0.078	0.057	0.057
Residential High-rise: Roof/Ceiling					
	Climate Zones				
	1,16	2-5	6-10	11-13	14-15
R-value Wood or Metal	**30**	**19**	**19**	**30**	**30**
U-value	0.037	0.051	0.051	0.037	0.037

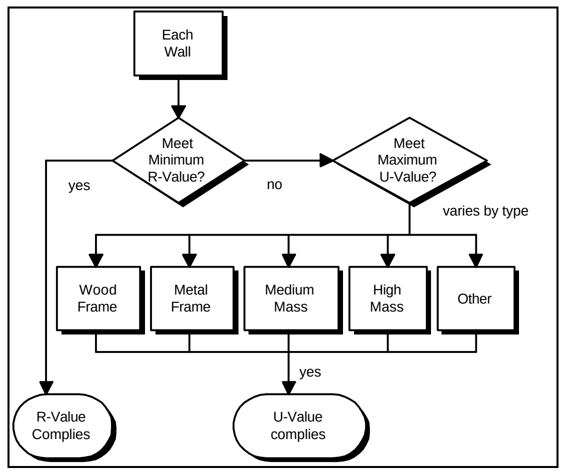
B. Exterior Walls (§143(a)2)

Exterior walls can meet the component requirements in one of two ways: install the required R-value of insulation, or demonstrate that the overall U-value of the assembly meets the required U-value (Section 141(c)4). If the insulation by itself meets the R-value requirement, then that component complies under this approach. If not, then the U-value calculation allows credit for the overall insulating qualities of the assembly which includes accounting for the effects of wood or metal framing in the assembly.

The required U-value depends on the type of wall construction. There are five classes of wall: wood frame, metal frame, medium mass, high mass and other. The "other" category is used for any wall type that does not fit into one of the other four wall classes. The mass walls are distinguished by their heat capacity (HC); the higher the HC, the higher the wall U-value may be (see Heat Capacity discussion in Section 3.1.2G). Medium mass walls have an HC between 7 Btu/ft^2-°F and 15 Btu/ft^2-°F. High mass walls have an HC greater than 15 Btu/ft^2-°F .

Framed wall assemblies will seldom have an HC greater than 7 Btu/ft^2-°F . Medium mass walls will have at least one fairly heavy layer, such as two coat stucco or a brick veneer, in order to have an HC higher than 7 Btu/ft^2-°F . High mass walls are generally of masonry or concrete construction.

Figure 3-9: Wall Flowchart



The proposed wall U-value must be calculated by an appropriate method (see Section 141(c)4). Framed assemblies must account for framing affects. Masonry assemblies must account for two dimensional heat flow. See Section 3.1.2D, E, and F for a complete discussion of the various methods and forms for determining U-values.

C. Demising Walls (§143(a)3 & 5)

Demising walls, separating conditioned space from enclosed unconditioned space, must be insulated with a minimum of R-11 insulation if the wall is a framed assembly. If it is not a framed assembly, then no insulation is required. This only applies to the opaque portion of the wall. A *demising wall* is not an *exterior wall.*

The rationale for insulating demising walls is that the space on the other side may remain unconditioned indefinitely. For example, the first tenant in a warehouse building cannot know whether the future neighbor will use the adjoining space as unheated warehouse space or as an office. This requirement assures at least some insulation in the wall.

D. Exterior Floors and Soffits (§143(a)4)

Exterior floors and soffits can meet the component requirements using two methods: install the required R-value of insulation, or demonstrate that the overall U-value of the assembly meets the required U-value (see Section 141(c)4). The U-value calculation allows for calculating the overall insulating qualities of the entire assembly, which includes accounting for the effects of wood or metal framing in the assembly.

The required U-value depends on the type of floor construction: mass and other. The mass floor is distinguished by its heat capacity (HC), which must be greater than 7 (see Heat Capacity discussion in Section 3.1.2G).

Particular note should be taken with this requirement when insulating slab floors that are over unconditioned spaces, such as crawl spaces or parking garages.

Because there are no cavities to accept the insulation, it must be applied either to the underside of the slab or above the slab and beneath the finished floor. There are numerous ways this can be accomplished, but the selection requires careful consideration of the requirements for finishes above or below the insulation.

Table 3-16: Wall Requirements

Nonresidential: Walls					
	Climate Zones				
	1,16	2-5	6-10	11-13	14-15
R-value					
Wood or Metal	**13**	**11**	**11**	**13**	**13**
U-value					
Wood Frame	0.084	0.092	0.092	0.084	0.084
Metal Frame	0.182	0.189	0.189	0.182	0.182
Mass/7.0<HC<15.0	0.340	0.430	0.430	0.430	0.430
Mass/15.0<HC	0.360	0.650	0.690	0.650	0.400
Other	0.084	0.092	0.092	0.084	0.084
Residential High-rise: Walls					
	Climate Zones				
	1,16	2-5	6-10	11-13	14-15
R-value					
Wood or Metal	**19**	**11**	**11**	**13**	**13**
U-value					
Wood Frame	0.063	0.092	0.092	0.084	0.084
Metal Frame	0.140	0.181	0.181	0.175	0.175
Mass/7.0<HC<15.0	0.340	0.430	0.430	0.430	0.430
Mass/15.0<HC	0.360	0.650	0.690	0.650	0.400
Other	0.063	0.092	0.092	0.084	0.084

E. Windows (§143(a)5)

There are three aspects of the Envelope Component Approach for windows:

1. **Maximum Area**
2. **Maximum U-value**
3. **Maximum Relative Solar Heat Gain**

Under the Envelope Component Approach, the total window area may not exceed 40 percent of the gross wall area for the building (see Section 3.1.2A for the definitions of how these are measured). This maximum area requirement will affect those buildings with very large glass areas, such as automobile showrooms or airport terminals.

Optionally, multiply the length of the display perimeter by six feet in height and use the larger of the product of that multiplication or 40 percent of gross wall area.

Figure 3-10: Floor/Soffit Flowchart

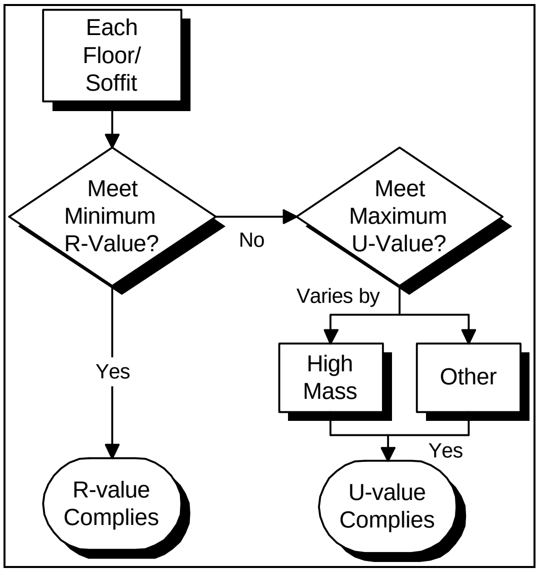


Table 3-17 Floor/Soffit Requirements

Nonresidential: Floor/Soffit					
	Climate Zones				
	1,16	2-5	6-10	11-13	14-15
R-value					
Wood or Metal	**19**	**11**	**11**	**11**	**11**
U-value					
Mass/7.0<HC	0.097	0.158	0.158	0.097	0.158
Other	0.050	0.076	0.076	0.076	0.076
Residential High-rise: Floor/Soffit					
	Climate Zones				
	1,16	2-5	6-10	11-13	14-15
R-value					
Wood or Metal	**19**	**11**	**11**	**11**	**11**
U-value					
Mass/7.0<HC	0.097	0.158	0.158	0.097	0.097
Other	0.050	0.076	0.076	0.076	0.076
Raised Concrete					
R-value	8	*	*	*	*

Each window or skylight must meet the required U-value and solar heat gain coefficient. The required value for Relative Solar Heat Gain (RSHG) is less stringent (higher) for north-facing windows. The "north" value may also be used for windows in the first floor display perimeter which are prevented from having an overhang because of building code restrictions (such as minimum separation from another building or a property line) (exception to Section 143(a)5.C).

Glazing in a demising wall does not count toward the total building allowance. There is no limit to the amount of glazing allowed in demising walls, but it must meet the U-value requirement for the climate zone. If the glazing is fully shaded no SHGC requirements apply. However, in situations where demising walls are not fully shaded as the result of skylights or adjacent glazing on an exterior wall, the glazing must have a SHGC equal to that required for north-facing glazing.

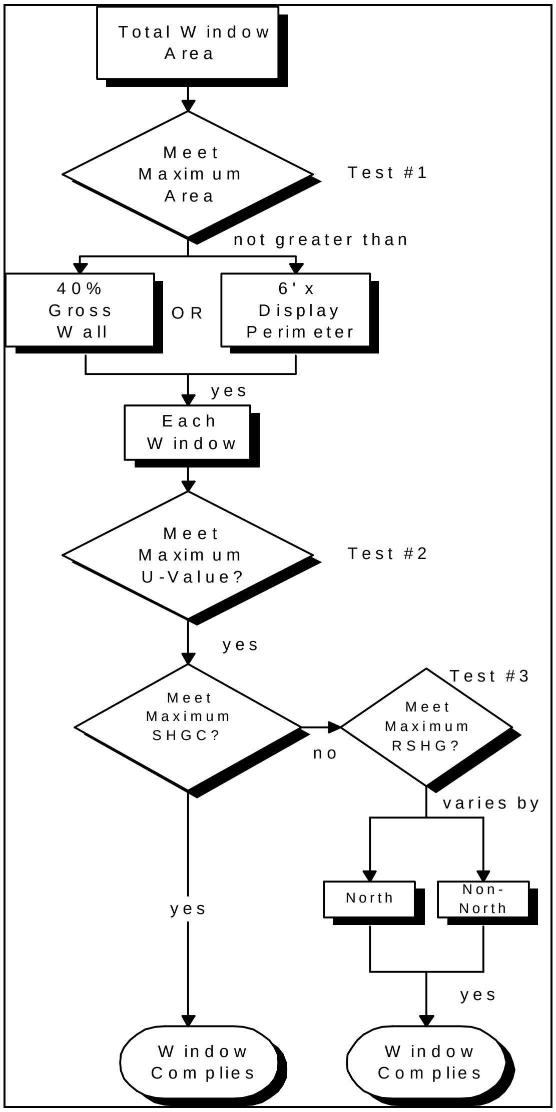
Note also that the RSHG limitation allows credit for window overhangs. In order to get credit for an overhang, it must extend beyond both sides of the window jamb by a distance equal to the overhang projection (Section 143(a)5.C.ii). This would occur naturally with a continuous eave overhang, but may require special attention in some designs. See Section 3.1.2J for more information on RSHG.

Table 3-18: Window Requirements

Nonresidential: Windows					
	Climate Zones				
	1,16	**2-5**	**6-10**	**11-13**	**14-15**
U-Value*	**0.72**	**1.23**	**1.23**	**0.72**	**0.72**
RelativeSolar					
Heat Gain*					
North	0.77	0.82	0.82	0.77	0.77
Non-North	0.50	0.62	0.62	0.50	0.50
Residential High-rise: Windows					
	Climate Zones				
	1,16	**2-5**	**6-10**	**11-13**	**14-15**
U-Value*	**0.72**	**1.23**	**1.23**	**0.72**	**0.72**
Relative Solar					
Heat Gain*					
North	0.77	0.82	0.82	0.77	0.77
Non-North	0.77	0.82	0.62	0.50	0.50

*The U-value and RSHG must be less than or equal to values shown in the tables.

Figure 3-11: Window Flowchart



F. Skylights (§143(a)6)

As with windows, there are three aspects of the Envelope Component Approach for skylights:

1. **Maximum Area**
2. **Maximum U-value**
3. **Maximum Solar Heat Gain Coefficient**

The area limitation for skylights is based on 5 percent of the gross exterior roof area. This effectively prevents large skylights under the Envelope Component Approach. The limit increases to 10 percent for buildings with an atrium over 55 feet high (see Section 3.1.2A for definition). The 55 foot height is also the height limitation at which the Uniform Building Code requires a mechanical smoke-control system for such atriums UBC Sec. 1715). This means that the 10 percent skylight allowance is not allowed for atriums unless they also meet this smoke control requirement. All skylights must meet the maximum U-value.

Note that skylights are only regulated for SHGC, not RSHG, because skylights cannot have overhangs.

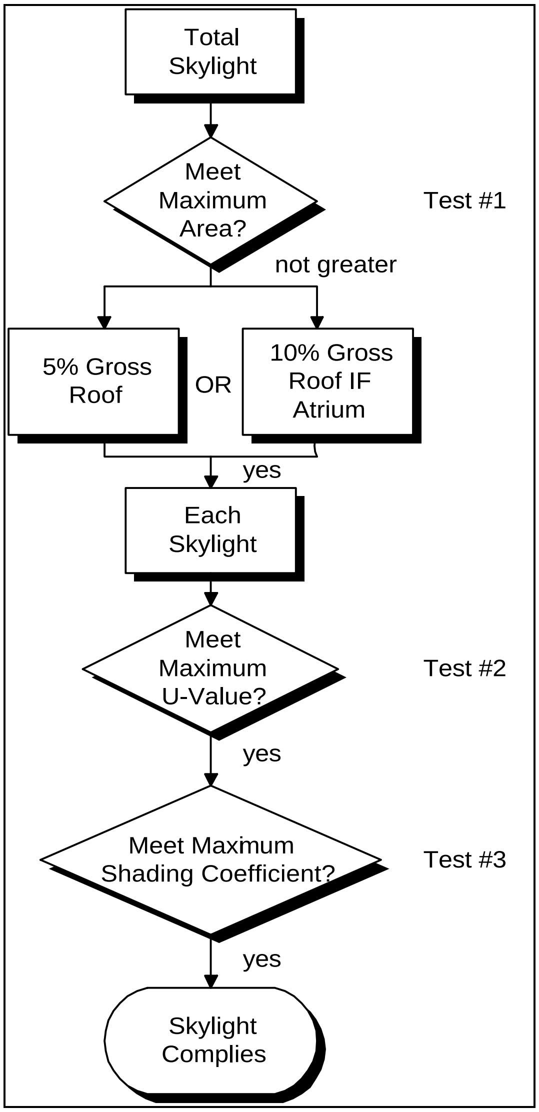
Table 3-19: Skylight Requirements

Nonresidential: Skylights					
	Climate Zones				
	1,16	**2-5**	**6-10**	**11-13**	**14-15**
U-Value*	**0.85**	**1.31**	**1.31**	**0.85**	**0.85**
Solar Heat Gain Coefficient*					
Transparent	0.44	0..61	0..61	0.44	0.44
Translucent	0.70	0.75	0.75	0.70	0.70
Residential: Skylights					
	Climate Zones				
	1,16	**2-5**	**6-10**	**11-13**	**14-15**
U-Value*	**0.85**	**1.31**	**1.31**	**0.85**	**0.85**
Solar Heat Gain Coefficient*					
Transparent	0.44	0.61	0.61	0.44	0.44
Translucent	0.70	0.75	0.75	0.70	0.70

*U-value and SC must be less than or equal to values shown in the table.

For skylights, the standard solar heat gain coefficient (SHGC) differs depending on whether the skylight glazing material is transparent or translucent. A transparent material allows a clear image to be seen when looking at an object through the glazing, while a translucent material will not permit a clear image.

Figure 3-12: Skylight Flowchart



G. Exterior Doors §143(a)7)

Opaque doors have no R-value, U-value or area requirements. Exterior doors are only a part of the compliance process when they are included in the calculation of the gross exterior wall area. Glazing in doors, however, is defined as a window in the *Standards* when it exceeds one-half of the area of the door and must be included in all window calculations.

3.2.3 Prescriptive Overall Envelope Approach (§143(b))

The Overall Envelope Approach is the second prescriptive envelope approach. It offers the greater design flexibility of the prescriptive envelope approaches. It allows the designer to make trade-offs between many of the building envelope components. For example, if a designer finds it difficult to insulate the walls to a level adequate for meeting the wall component U-value requirement, then the insulation level in a roof or floor or the performance of a window component could be increased to offset the under-insulated wall. The same holds true for glazing. If a designer wants to put clear, west-facing glass to enhance the display of merchandise in a show window, it would be possible to use lower SHGC glazing on the other orientations to make up for the increased SHGC on the west.

The Overall Envelope Approach has two parts and both parts must be met: overall heat loss (see Equations 3-2) and overall heat gain (see Equations 3-4). The overall heat loss accounts for the insulating qualities of the building, and sets a maximum rate of conductive heat transfer through the building envelope. The requirements are more stringent in more extreme climate zones than in mild climate zones. The overall heat gain accounts for the area of windows and skylights and their ability to block solar heat gains, thereby reducing cooling loads on the building. These requirements are more stringent in warmer climate zones.

A *standard value* and a *proposed value* are calculated for both the overall heat loss and the overall heat gain using ENV-2: Overall Envelope Method found in Section 3.3.3. These calculations assume that the standard building complies with the requirements of the Envelope Component Approach (also calculated on ENV-2: Overall Envelope Method). The standard values are compared to the proposed values calculated from the actual envelope design. If the proposed values do not exceed the standard values, then the Overall Building Envelope requirements are met.

Table 3-20: Nonresidential Requirements

	Climate Zones				
	1,16	**2-5**	**6-10**	**11-13**	**14-15**
Roof/Ceiling					
R-value Wood or Metal	**19**	**19**	**11**	**19**	**19**
U-value	0.057	0.057	0.078	0.057	0.057
Wall					
R-value Wood or Metal	**13**	**11**	**11**	**13**	**13**
U-value					
Wood Frame	0.084	0.092	0.092	0.084	0.084
Metal Frame	0.182	0.189	0.189	0.182	0.182
Mass/7.0<HC<15.0	0.340	0.430	0.430	0.430	0.430
Mass/15.0<HC	0.360	0.650	0.690	0.650	0.400
Other	0.084	0.092	0.092	0.084	0.084
Floor Soffit					
R-value Wood or Metal	**19**	**11**	**11**	**11**	**11**
U-value					
Mass/7.0<HC	0.097	0.158	0.158	0.097	0.158
Other	0.050	0.076	0.076	0.076	0.076
Windows					
U-Value*	0.72	1.23	1.23	0.72	0.72
Relative Solar Heat Gain*					
North	0.77	0.82	0.82	0.77	0.77
Non-North	0.50	0.62	0.62	0.50	0.50
Skylights					
U-Value*	0.85	1.31	1.31	0.85	0.85
Solar Heat Gain Coefficient*					
Transparent	0.44	0.61	0.61	0.44	0.44
Transparent	0.70	0.75	0.75	0.70	0.70

Table 3-21: High-Rise Residential and Hotel/Motel Guest Room Requirements

	Climate Zones				
	1,16	**2-5**	**6-10**	**11-13**	**14-15**
Roof/Ceiling					
R-value Wood or Metal	**30**	**19**	**19**	**30**	**30**
U-value	0.037	0.051	0.051	0.037	0.037
Wall					
R-value Wood or Metal	**19**	**11**	**11**	**13**	**13**
U-value					
Wood Frame	0.063	0.092	0.092	0.084	0.084
Metal Frame	0.140	0.181	0.181	0.175	0.175
Mass/7.0<HC<15.0	0.340	0.430	0.430	0.430	0.430
Mass/15.0<HC	0.360	0.650	0.690	0.650	0.400
Other	0.063	0.092	0.092	0.084	0.084
Floor Soffit					
R-value Wood or Metal	**19**	**11**	**11**	**11**	**11**
U-value					
Mass/7.0<HC	0.097	0.158	0.158	0.097	0.097
Other	0.050	0.076	0.076	0.076	0.076
Raised Concrete R-value	8	**	**	**	**
Windows					
U-Value*	0.72	1.23	1.23	0.72	0.72
Relative Solar Heat Gain*					
North	0.77	0.82	0.82	0.77	0.77
Non-North	0.77	0.82	0.62	0.50	0.50
Skylights					
U-Value*	0.85	1.31	1.31	0.85	0.85
Solar Heat Gain Coefficient*					
Transparent	0.44	0.61	0.61	0.44	0.44
Transparent	0.70	0.75	0.75	0.70	0.70

*** U-values, RSHG and SHGC must be less than or equal to values shown in the above tables**
**** R-8 in climate zones 1, 2, 11, 13, 14, and 16; R-4 is required in climate zones 12 and 15; and R-0 in climate zones 3 –10.**

Associated with the increased design flexibility afforded by the Overall Envelope Approach is an increase in complexity of the calculations when demonstrating compliance. Special attention must be given to the calculations because the effects of all the envelope components are interrelated. Changing any one component may prevent the overall envelope from complying. Improvements to one or more of the other components will be needed to bring the envelope into compliance.

Equation 3-2 Standard Building Heat Loss

$$HL_{std} = \sum_{i=1}^{nW} \left(A_{Wi} \times U_{Wi_{std}} \right) + \sum_{i=1}^{nF} \left(A_{Fi} \times U_{Fi_{std}} \right)$$
$$+ \sum_{i=1}^{nR} \left(A_{Ri} \times U_{Ri} \times U_{Ri_{std}} \right) + \sum_{i=1}^{nG} \left(A_{Gi} \times U_{Gi_{std}} \right)$$
$$+ \sum_{i=1}^{nS} \left(A_{Si} \times U_{Si_{std}} \right)$$

Refer to Section 143 of the 1998 Energy Efficiency Standards for equation definitions

A. Overall Heat Loss

There are two parts to the Overall Heat Loss calculation. The first is to calculate the Standard Building Heat Loss; this becomes the standard that must be met. The second is to calculate the Proposed Building Heat Loss, which is compared to the standard to show that it does not exceed the Standard Building Heat Loss.

There are three steps to calculating the Standard Building Heat Loss:

> **Step 1 -** Calculate areas of each type of envelope assembly (walls, windows, roofs, etc.). If glazing is too large or small, areas may require adjustment as directed on the ENV-2.
>
> **Step 2 -** Determine allowed U-values from Tables 3-20 and 3-21.
>
> **Step 3 -** Multiply and add to get Standard Building Heat Loss.

Each step will be discussed in turn.

Calculate Areas

First, identify each type of assembly in the building envelope. In a complex building, there could be many. Assemblies are different if they have different materials or thermal properties. For example, a steel stud framed wall with a 1" stucco exterior would be different from a steel stud framed wall with 4" brick cladding.

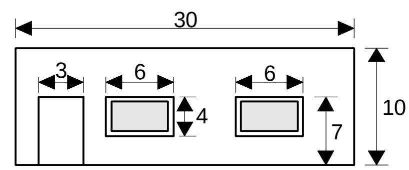
Next, calculate the areas of each assembly. All dimensions are taken at the exterior surface of the assembly. The sum of all the vertical surface areas is the gross exterior wall area (walls, windows, doors). The exterior wall area is the opaque wall area only (no doors). The window wall ratio is the total window area in the gross exterior walls, divided by the gross exterior wall area.

In the case of windows, the area is based on the rough opening dimensions. For most buildings, the actual window area is used to calculate the Standard Building Heat Loss.

Example 3-2: Area Calculation

Question

How is exterior wall area calculated for the following wall (dimensions in feet)?



Answer

The gross exterior wall area is 30 x 10 = 300 ft². The door area is 3 x 7 = 21 ft². The window areas are 6 x 4 = 24 ft² each, or 48 ft² total. The exterior wall area is the gross minus doors and windows, or 300 ft² — 21 ft² — 48 ft² = 231 ft².

Adjust Areas

When the window wall ratio is less than 10 percent or more than 40 percent, an adjusted window area is used to calculate the Standard Building Heat Loss.

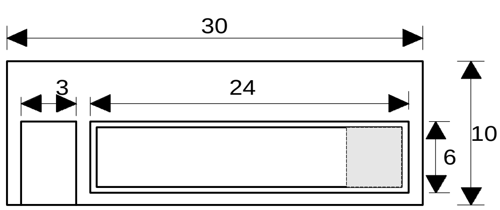
The first adjustment is for buildings with very little window area. The *Standards* allow for a minimum of 10 percent window wall ratio in calculating the standard envelope heat loss (“A_{Gi}" of Equation 3-2). If the actual window wall ratio is less than 10 percent, then an area equal to 10 percent of the gross exterior wall area is used for the standard building.

The second adjustment is for buildings with very large window area. If the actual window wall ratio is greater than 40 percent, then an area equal to 40 percent of the gross wall area is used to calculate the Standard Building Heat Loss. Alternatively, for buildings with substantial display perimeter areas (see 3.1.2A), an area equal to six feet high by the length of the display perimeter is calculated. If this value is greater than 40 percent of the gross exterior wall area, then it is used in the standard envelope heat loss calculation (“A_{Gi}” of Equation 3-2)

Example 3-3: Glazing Area Adjustments

Question

What is the window wall ratio (WWR) for the following wall (dimensions in feet)? How is the window and wall area adjusted under the overall envelope approach?



Answer

The gross exterior wall area is 30 x 10 = 300 ft^2. The window area is 24 x 6 = 144 ft^2. The WWR is 144 / 300 = 0.48, or 48 percent. The exterior wall area is 300 — 144 = 156 ft^2. The window area must be adjusted downward to 40 percent of the gross exterior wall area, or 0.40 x 300 = 120 ft^2. This is a window area reduction of 144 —120 = 24 ft^2. The exterior wall area must be increased by the same amount to 156 + 24 = 180 ft^2 (as shown by shaded area in sketch above).

If either of these adjustments is made to the standard window area, the exterior wall area is also adjusted (see Example 3-2). Skylights are treated similarly (“A_{Si}” of Equation 3-2). In most cases, the actual skylight area will be used to calculate the standard envelope heat loss. If the skylight shape is three-dimensional (not flat), then the area is the actual surface area, not the opening area (see Section 3.1.2A). If the skylight area is larger than 5 percent of the gross exterior roof area (roof doors not included for the standard building), then an area equal to 5 percent of the roof area is used. Alternatively, if the building has an atrium over 55 feet high, then the allowance for skylights is increased to 10 percent (or the actual skylight area if less than 10 percent of the gross roof area).

Determine Allowed U-values

The allowed U-values are taken from Tables 3-20 and 3-21, depending on the occupancy type. These are the same values discussed under the Envelope Component Approach in the previous Section 3.2.2. It is necessary to differentiate wall assembly types and floor/soffit assembly types. The U-value requirements depend on framing type and heat capacity of the wall or the floor/soffit. In the case of heavier construction assemblies, the heat capacity (see Section 3.1.2G) must be calculated before the allowed U-value can be determined.

Multiply and Add

Once the areas and allowed U-values are determined for each assembly, then the Standard Building Heat Loss can be calculated. For each assembly, the U-value (U) and area (A) are multiplied together; the result is known as the *UA product* for the assembly. If any of the areas were adjusted, then the adjusted areas are used in this calculation. These UA products are added to obtain the total UA product for the building, which is the Standard Building Heat Loss.
The Standard Building Heat Loss has units of Btu/hr-°F, and it describes the amount of heat lost per hour through the building envelope for every degree Fahrenheit of temperature difference between inside and outside, under steady state heat flow conditions.

Equation 3-3: Proposed Building Heat Loss

$$HL_{prop} = \sum_{j=1}^{nW}\left(A_{Wj} \times U_{Wj_{prop}}\right) + \sum_{j=1}^{nF}\left(A_{Fj} \times U_{Fj_{prop}}\right) + \sum_{j=1}^{nR}\left(A_{Rj} \times U_{Rj_{prop}}\right) + \sum_{j=1}^{nG}\left(A_{Gj} \times U_{Gj_{prop}}\right) + \sum_{j=1}^{nS}\left(A_{Sj} \times U_{Sj_{prop}}\right)$$

Refer to Section 143 of the 1998 Energy Efficiency Standards for equation definitions.

Once the Standard Building Heat Loss rate is determined, the proposed design's heat loss rate can be calculated and the two can be compared. If the proposed heat loss rate does not exceed the standard, then the envelope complies with the heat loss criteria.

The proposed heat loss is calculated the same as the standard, except that the actual areas and U-values of each assembly are used without adjustment. The actual U-values are calculated as described in section 3.1.2 C-F. It is not necessary to calculate the U-value of opaque doors, as they are ignored in the overall heat loss calculations. Any glazing in doors, however, is considered a window and must be included in all window calculations.

The UA product is calculated for each surface, and these are totaled to arrive at the Proposed Building Heat Loss. It has the same units and meaning as the Standard Building Heat Loss (see above).

For a complete example of how the Standard Building Heat Loss and Proposed Building Heat Loss are calculated and compared using the ENV-2 form (see Section 3.3.2).

B. Overall Heat Gain

As with the overall heat loss, there are two parts to the Overall Heat Gain calculation. The first part is to calculate the Standard Building Heat Gain; this becomes the standard that must not be exceeded.

The second part is to calculate the Proposed Building Heat Gain; compare this to the standard and show that the proposed heat gain does not exceed the standard heat gain.

Equation 3-4: Standard Building Heat Gain

$$HG_{std} = \sum_{i=1}^{nW}\left(A_{Wi} \times TF_i\right) + \sum_{i=1}^{nF}\left(A_{Fi} \times U_{Fi_{std}} \times TF_i\right) + \sum_{i=1}^{nR}\left(A_{Ri} \times U_{Ri_{std}} \times TF_i\right) + \sum_{i=1}^{nG}\left(A_{Gi} \times U_{Gi_{std}} \times TF_i\right) + \sum_{i=1}^{nS}\left(A_{Si} \times U_{Si_{std}} \times TF_i\right) + \sum_{i=1}^{nG}\left(WF_{Gi} \times A_{Gi_{std}} \times RSHG_{Gi_{std}}\right) \times SF + \sum_{i=1}^{nS}\left(WF_{Si} \times A_{Si_{std}} \times SHGC_{Si_{std}}\right) \times SF$$

Refer to Section 143 of the 1998 Energy Efficiency Standards for equation definitions.

There are four steps to calculating the Standard Building Heat Gain:

Step 1 - Calculate the area and determine the U-value and temperature factor (Table 3-22) of each type of envelope assembly (walls, windows, roofs, etc.) [Same values as heat loss equations.] Window areas may require adjustment if too large or small.

Step 2 - Determine RSHG for north and non-north orientations, and SHGC for skylights (as per climate zone, occupancy and type); values are taken from Tables 3-20 and 3-21.

Step 3 - Determine the weighting factors and solar factors for each orientation (as per climate zone) from Table 3-23.

Step 4 - Multiply and add to get Standard Building Heat Gain.

Each step will be discussed in turn.

Calculate Areas

The total area of envelope features and glazing and corresponding U-values were determined earlier for the Standard Building Heat Loss calculation. A temperature factor (Table 3-22) is applied. Window area was adjusted when it was too large or too small for the standard area. This same total is used for the Standard Building Heat Gain Calculation, except that it is further broken down by orientation. Each window is assigned to the nearest cardinal orientation: east, west, north and south (see Section 3.1.2). A solar factor (Table 3-22) is applied to window and skylight areas.

As in the heat loss calculation, the window areas are calculated by the rough opening dimensions.

Adjust Areas

If the total window area was adjusted in the standard heat loss calculation, a similar adjustment is made here, except that it is applied to each orientation. For example, if the proposed window wall ratio is 50 percent, then the window must be reduced to 40 percent for the standard reduction. This translates to the glazing area on each orientation being reduced by 20 percent for the standard heat gain calculation.

Determine RSHG and SHGC

The values for RSHG and SHGC are found in Tables 3-20 and 3-21. For windows, the standard relative solar heat gain (RSHG) differs depending on whether or not the window is north-facing (see Sections 3.1.2A, I and J for definitions). For skylights, the standard solar heat gain coefficient (SHGC) differs depending on whether the skylight glazing material is transparent or translucent. A transparent material allows a clear image to be seen when looking at an object through the glazing, while a translucent material will not permit a clear image.

The values of RSHG and SHGC also differ by climate zone. For the milder climate zones 2–10, higher values are allowed.

For the Standard Building Heat Gain calculation, the values of RSHG and SHGC are simply taken from the tables and entered into the calculations.

Example 3-4: RSHG Determination

Question
What is the RSHG value for an east-facing window in an office building in climate zone 8? .
Answer
0.62 (Table 3-20)

Determine Temperature Factor

The temperature factor considers the effects of solar radiation striking opaque surfaces. The appropriate values are taken from Table 3-22 and entered into the calculations.

Table 3-22
Temperature and Solar Factors

Climate Zone	TEMPERATURE FACTOR (TF) Envelope Construction (Mass) Light	Medium	Heavy	SOLAR FACTOR (SF) (Btu/hr-ft²)
1	14	3	1	128
2	40	30	28	126
3	28	18	16	126
4	32	22	20	125
5	27	17	15	124
6	28	18	16	123
7	27	17	15	123
8	33	23	21	123
9	42	31	29	123
10	45	35	33	123
11	49	38	36	127
12	45	34	32	126
13	45	35	33	125
14	52	42	40	125
15	55	45	43	123
16	34	23	21	128

Light Mass: Heat Capacity < 7 Btu/ft²-°F
Medium Mass: Heat Capacity >= 7 and <15 Btu/ft²-°F
Heavy Mass: Heat Capacity >= 15 Btu/ft²-°F

Determine Weighting Factors

Weighting factors in the heat gain equations account for the variation in solar radiation striking windows and skylights by orientation and climate zone. The appropriate values are taken from Table 3-23 and entered into the calculations.

Table 3-23: Glazing Orientation Weighting Factors

Climate Zone	1,16	2-5	6-10	11-13	14, 15
North	0.63	0.52	0.34	0.42	0.67
East	1.14	1.05	1.02	1.27	1.08
South	0.99	1.24	1.31	1.14	1.12
West	1.24	1.19	1.34	1.17	1.13
Skylight	2.54	2.74	2.30	2.54	2.45

Example 3-5: Determining Weighting Factors

Question

What is the weighting factor for a south-facing window in climate zone 12?

Answer

1.14 (Table 3-22)

Determine Solar Factor

The solar factor is used to account for solar radiation striking glazed surfaces. The appropriate values are taken from Table 3-22 and entered into the calculations.

Multiply and Add

Once the areas and the allowed RSHG, SHGC and weighting factor are determined for each glazing orientation, then the Standard Building Heat Gain can be calculated. For each window orientation, the adjusted area is multiplied by the RSHG value and the weighting factor. For each type of skylight (transparent and translucent), the adjusted areas are multiplied by the SHGC value and the weighting factor. If the window or skylight area was adjusted, the adjusted areas are used in this calculation. All of these products are added to obtain the Standard Building Heat Gain.

Once the Standard Building Heat Gain rate is determined, the proposed design heat gain rate can be calculated and the two can be compared. If the proposed heat gain rate does not exceed the standard, then the envelope complies with the heat gain criteria.

The proposed heat gain is calculated the same as the standard, except that the actual areas for each orientation, and the actual RSHG and SHGC are used. The determination of actual SHGC and RSHG are described above in Sections 3.1.2I and 3.1.2J.

For the windows on each orientation, the actual area, SHGC, overhang factor and weighting factor are multiplied together. For skylights, the actual area, SHGC and weighting factor are multiplied. These are summed to obtain the Proposed Building Heat Gain.

Equation 3-5: Proposed Building Heat Gain

$$
\begin{aligned}
HG_{prop} = {} & \sum_{i=1}^{nW}\left(A_{Wj} \times U_{Wj_{prop}} \times TF_j\right) + \\
& \sum_{i=1}^{nF}\left(A_{Fj} \times U_{Fj_{prop}} \times TF_j\right) + \\
& \sum_{i=1}^{nR}\left(A_{Rj} \times U_{Rj_{prop}} \times TF_j\right) + \\
& \sum_{i=1}^{nG}\left(A_{Gj} \times U_{Gj_{prop}} \times TF_j\right) + \\
& \sum_{i=1}^{nS}\left(A_{Sj} \times U_{Sj_{prop}} \times TF_j\right) + \\
& \sum_{i=1}^{nG}\left(WF_{Gj} \times A_{Gj} \times SHGC_{Gj_{prop}} \times OHF_j\right) \times SF + \\
& \sum_{i=1}^{nS}\left(WF_{Sj} \times A_{Sj} \times SHGC_{Sj_{prop}}\right) \times SF
\end{aligned}
$$

Refer to Section 143 of the 1998 Energy Efficiency Standards for equation definitions.

For an example of how the Standard and Proposed Building Heat Gain are calculated and compared using the ENV-2 form (see Section 3.3.3).

3.2.4 Performance Approach

Under the performance approach, the energy use of the building is modeled using an energy budget generated by a computer program approved by the Energy Commission (see Appendix E). This section presents some basic details on the modeling of building envelope components. *Program users and those checking for enforcement should consult the most current version of the user's manuals and associated compliance supplements for specific instructions on the operation of the program.* All computer programs, however, are required to have the same basic modeling capabilities. A discussion on the performance approach, and fixed and restricted inputs, is included in Section 6.1.

A. Modeling Envelope Components

The following modeling capabilities are required by all approved nonresidential computer programs. These modeling features affect the thermal loads seen by the HVAC system model.

Opaque Surface Mass Characteristics

Heat absorption, retention and thermal transfer characteristics associated with the heat capacity of exterior opaque mass surfaces such as walls, roofs and floors are modeled. Typical inputs are thickness, density, specific heat and conductivity. See Section 3.1.2G for determining the heat capacity of materials.

Opaque Surface Heat Transfer

Heat gains and heat losses are modeled through opaque surfaces of the building envelope. The following inputs or acceptable alternative inputs are used by this modeling capability:

- Surface areas by opaque surface type. Section 3.1.2A discusses determining the area of opaque surfaces.
- Surface orientation and slope. Section 3.2.1A discusses how slope affects wall and roof/ceiling definitions.
- Thermal conductance of the surface. Section 3.1.2C through G discusses determining the U-value of various assemblies.
- Surface absorptance. Surface absorptance is a restricted input. Section 6.1.3A discusses fixed and restricted modeling assumptions.

Glazing Heat Transfer

Heat transfer through all glazed (transparent or translucent) surfaces of the building envelope are modeled using the following inputs:

- Glazing areas. Section 3.1.2A discusses determining the area of windows and skylights.
- Glazing orientation and slope. Section 3.1.2A discusses how slope affects window and skylight definitions.
- Glazing thermal conductance. Section 3.1.2H discusses how to determine the fenestration U-value.
- Glazing solar heat gain coefficient. Section 3.1.2I. discusses how to determine the solar heat gain coefficient of glazing.

Overhangs

Approved computer programs are able to model overhangs. Typical inputs are overhang projection, height above window, window height and the overhang horizontal extension past the edge of the window. If the overhang horizontal extension (past the window jambs) is not an input, then the program must assume that the extension is zero (i.e., overhang width is equal to window width) which results in no benefits from the overhang.

Interzone Surfaces

Heat transfer modeled through all surfaces separating different space conditioning zones may be modeled with inputs such as surface area, surface tilt and thermal conductance. Thermal mass characteristics may be modeled using the thickness, specific heat, density and types of layers that comprise the construction assembly.

3.2.5 Alterations

Alterations to the envelope of an existing conditioned space have the following options for showing compliance:

Option 1. Show that the overall heat gain and heat loss of the building is not increased. This can be demonstrated on form ENV-2, Overall Envelope Method, Part 2 of 5 and Part 3 of 5 by showing the heat gain and heat loss for the altered component(s) before and after the alteration; or

> NOTE:
>
> For alterations that include an increase in glazing area, this compliance option is not practical. This is because the equation for heat gain considers only glazing surfaces, however, neither heat gain nor loss can increase with this option.

Option 2. Meet current prescriptive envelope requirements for the altered component; or

> NOTE:
>
> The prescriptive solar heat gain coefficient requirements do not apply to fenestration repaired, replaced, or up to 50 square feet of new glass.

Option 3. Use an approved computer program to show compliance with an energy budget for the altered space; or

Option 4. Use an approved computer program to show that the energy use of the entire building is what it would be if the remainder of the building was unaltered and the altered space complied with its energy budget ("existing plus alteration"). This fourth option involves four steps and three separate computer runs:

Step 1. Model the building before any alterations or additions to determine the energy use of the existing building (use the value referred to as the "proposed" energy use).

Step 2. Model the new or altered space to determine the energy budget ("standard" design) of the alteration or addition alone.

Step 3. Calculate the energy budget for the entire building as indicated in Equation 3-6.

Equation 3-6: Energy Use Goal

$$\frac{(A_e \times PD_e) + (A_a \times SD_a)}{A_{e+a}} = \text{Energy Use Goal}$$

where:

A_e = *Area of the existing entire building before the proposed addition/alteration (from Step 1. above)*

PD_e = *Proposed design of the existing entire building before the proposed addition/alteration (from Step 1. above)*

A_a = *Area of the proposed addition/alteration (from Step 2. above)*

SD_a = *Standard design for the proposed addition/alteration (from Step 2, above)*

A_{e+a} = *Area of the entire building after the proposed addition/ alteration*

Step 4. Model the entire building, including the proposed addition/ alteration, along with any improvements to the existing building. If the proposed design is less than or equal to the energy use goal (from Step 3. above), the addition or alteration complies.

3.3 ENVELOPE PLAN CHECK DOCUMENTS

At he time a building permit application is submitted to the building department, the applicant also submits plans and energy compliance documentation. This section describes the recommended forms and procedures for documenting compliance with the envelope requirements of the *Standards.* It does not describe the details of the requirements; these are presented in Section 3.2 Envelope Design Procedures. The following discussion is addressed to the designer preparing construction documents and compliance documentation, and to the building department plan checkers who are examining documents for compliance with the *Standards.*

The use of each form is briefly described below, then complete instructions for each form are presented in the following subsections.

ENV-1: Certificate of Compliance
This form should be required for every job, and it is required to appear *on the plans. (Title 24, Part 1, Section 10-103 of the California Code of Regulations.)*

ENV-2: Envelope Component Method, Overall Envelope Method, or Performance Method
One of these three versions should be part of every envelope compliance submittal. Choose the version that corresponds to the compliance method selected for the job.

ENV-3: Metal-Framed Assembly, Masonry Assembly, or Proposed Wood Frame Assembly
One of these forms should be submitted for each construction assembly in the building that does not use an Energy Commission default U-value. The version is chosen to match the type of assembly. If the assembly is something other than a metal-framed or masonry assembly, the Proposed Construction Assembly version of ENV-3 should be used.

3.3.1 ENV-1: Certificate of Compliance

The ENV-1 Certificate of Compliance form has two parts. Both parts must appear on the plans (usually near the front of the architectural drawings). A copy of these forms should also be submitted to the building department along with the rest of the compliance submittal at the time of building permit application. With building department approval, the applicant may use alternative formats of these forms (rather than the Energy Commission's forms), provided the information is the same and in similar format.

A. ENV-1 Part 1

Project Description

1. **PROJECT NAME** is the title of the project, as shown on the plans and known to the building department.
2. **DATE** is the date of preparation of the compliance submittal package. It should be on or after the date of the plans, and on or before the date of the building permit application.
3. **PROJECT ADDRESS** is the address of the project as shown on the plans and known to the building department.
4. **PRINCIPAL DESIGNER - ENVELOPE** is the person responsible for the preparation of the building envelope plans, and who signs the STATEMENT OF COMPLIANCE (see below). The person's telephone number is given to facilitate response to any questions that arise.
5. **DOCUMENTATION AUTHOR** is the person who prepared the energy compliance documentation and who signs the STATEMENT OF COMPLIANCE. The person's telephone number is given to facilitate response to any questions that arise.
6. **ENFORCEMENT AGENCY USE** is reserved for building department record keeping purposes.

General Information

1. **DATE OF PLANS** is the last revision date of the plans. If the plans are revised after this date, it may be necessary to re-submit the compliance documentation to reflect the altered design. The building department will determine whether or not the revisions require this.
2. **BUILDING CONDITIONED FLOOR AREA** has specific meaning under the energy *Standards*. Refer to Section 2.1.2A for a discussion of this definition.
3. **CLIMATE ZONE** is the official climate zone number where the building is located. Refer to California Climate Zone Description (Appendix C) for a listing of cities and their climate zones.
4. **BUILDING TYPE** is specified because there are special requirements for high-rise residential and hotel/motel guest room occupancies. All other occupancies that fall under the *Nonresidential Standards* are designated "Non

residential” here. It is possible for a building to include more than one building type, in which case check all applicable types here. See Section 2.1.2B for the formal definitions of these occupancies.

5. **PHASE OF CONSTRUCTION** indicates the status of the building project described in the documents. Refer to Section 2.2 for detailed discussion of the various choices.

    a. **NEW CONSTRUCTION** should be checked for all new buildings (see Section 2.2.6), newly conditioned space (see Section 2.2.2) or a stand-alone addition submitted for envelope compliance.

    b. **ADDITION** should be checked for an addition which is not treated as a stand-alone building, but which uses existing plus addition performance compliance, as described in Section 2.2.5.

    c. **ALTERATION** should be checked for alterations to existing building envelopes. See Section 2.2.4.

    d. **UNCONDITIONED** should be checked when the building is not intended as conditioned space, or when the owner chooses to defer demonstrating envelope compliance until such time as the space conditioning system permit application is submitted. See Section 2.2.1 for a full discussion. The building department may require the owner to file an affidavit declaring the building to be unconditioned and acknowledging that all the *Standards* requirements must be met when the building is conditioned.

6. **METHOD OF COMPLIANCE** - indicate which method is being used and documented with this submittal:

    a. **COMPONENT** for the Envelope Component Method

    b. **OVERALL ENVELOPE** for the Overall Envelope Method

    c. **PERFORMANCE** for the Performance Method

Statement of Compliance

The Statement of Compliance is signed by the person responsible for preparation of the plans for the building and the documentation author. This principal designer is also responsible for the energy compliance documentation, even if the actual work is delegated to someone else (the Documentation Author described above). It is necessary that the compliance documentation be consistent with the plans. The Business and Professions Code governs who is qualified to prepare plans, and therefore to sign this statement; check the appropriate box that describes the signer’s eligibility.

Applicable sections from the *Business and Professions Code* (based on the edition in effect as of July 1998), referenced on the Certificate of Compliance are provided below:

5537. *(a) This chapter does not prohibit any person from preparing plans, drawings, or specifications for any of the following:*

(1) Single-family dwellings of woodframe construction not more than two stories and basement in height.

(2) Multiple dwellings containing no more than four dwelling units of woodframe construction not more than two stories and basement in height. However, this paragraph shall not be construed as allowing an unlicensed person to design multiple clusters of up to four dwelling units each to form apartment or condominium complexes where the total exceeds four units on any lawfully divided lot.

(3) Garages or other structures appurtenant to buildings described under subdivision (a), of woodframe construction not more than two stories and basement in height.

(4) Agricultural and ranch buildings of woodframe construction, unless the building official having jurisdiction deems that an undue risk to the public health, safety, or welfare is involved.

(b) If any portion of any structure exempted by this section deviates from substantial compliance with conventional framing requirements for woodframe construction found in the most recent edition of Title 24 of the California Code of Regulations or tables of limitation for woodframe construction, as defined by the applicable building code duly adopted by the local jurisdiction or the state, the building official having jurisdiction shall require the preparation of plans, drawings, specifications, or calculations for that portion by, or under the

responsible control of, a licensed architect or registered engineer. The documents for that portion shall bear the stamp and signature of the licensee who is responsible for their preparation. Substantial compliance for purposes of this section is not intended to restrict the ability of the building officials to approve plans pursuant to existing law and is only intended to clarify the intent of Chapter 405 of the Statutes of 1985.

5537.2. *This chapter shall not be construed as authorizing a licensed contractor to perform design services beyond those described in Section 5537 or in Chapter 9 (commencing with Section 7000), unless those services are performed by or under the direct supervision of a person licensed to practice architecture under this chapter, or a professional or civil engineer licensed pursuant to Chapter 7 (commencing with Section 6700) of Division 3, insofar as the professional or civil engineer practices the profession for which he or she is registered under that chapter.*

However, this section does not prohibit a licensed contractor from performing any of the services permitted by Chapter 9 (commencing with Section 7000) of Division 3 within the classification for which the license is issued. Those services may include the preparation of shop and field drawings for work which he or she has contracted or offered to perform, and designing systems and facilities which are necessary to the completion of contracting services which he or she has contracted or offered to perform.

However, a licensed contractor may not use the title "architect," unless he or she holds a license as required in this chapter.

5538. *This chapter does not prohibit any person from furnishing either alone or with contractors, if required by Chapter 9 (commencing with Section 7000) of Division 3, labor and materials, with or without plans, drawings, specifications, instruments of service, or other data covering such labor and materials to be used for any of the following:*

(a) For nonstructural or nonseismic storefronts, interior alterations or additions, fixtures, cabinetwork, furniture, or other appliances or equipment.

(b) For any nonstructural or nonseismic work necessary to provide for their installation.

(c) For any nonstructural or nonseismic alterations or additions to any building necessary to or attendant upon the installation of those storefronts, interior alterations or additions, fixtures, cabinetwork, furniture, appliances, or equipment, provided those alterations do not change or affect the structural system or safety of the building.

6737.1. *(a) This chapter does not prohibit any person from preparing plans, drawings, or specifications for any of the following:*

(1) Single-family dwellings of woodframe construction not more than two stories and basement in height.

(2) Multiple dwellings containing no more than four dwelling units of woodframe construction not more than two stories and basement in height. However, this paragraph shall not be construed as allowing an unlicensed person to design multiple clusters of up to four dwelling units each to form apartment or condominium complexes where the total exceeds four units on any lawfully divided lot.

(3) Garages or other structures appurtenant to buildings described under subdivision (a), of woodframe construction not more than two stories and basement in height.

(4) Agricultural and ranch buildings of woodframe construction, unless the building official having jurisdiction deems that an undue risk to the public health, safety or welfare is involved.

(b) If any portion of any structure exempted by this section deviates from substantial compliance with conventional framing requirements for woodframe construction found in the most recent edition of Title 24 of the California Administrative Code or tables of limitation for woodframe construction, as defined by the applicable building code duly adopted by the local jurisdiction or the state, the building official having jurisdiction shall require the preparation of plans, drawings, specifications, or calculations for that portion by, or under the direct supervision of, a licensed architect or registered engineer. The documents for that portion shall bear the stamp and signature of the licensee who is responsible for their preparation.

6737.3. *A contractor, licensed under Chapter 9 (commencing with Section 7000) of Division 3, is exempt from the provisions of this chapter relating to the practice of electrical or mechanical engineering so long as the services he or she holds himself or herself out as able to perform or does* *perform, which services are subject to the provisions of this chapter, are performed by, or under the responsible supervision of a registered electrical or mechanical engineer insofar as the electrical or mechanical engineer practices the branch of engineering for which he or she is registered.*

This section shall not prohibit a licensed contractor, while engaged in the business of contracting for the installation of electrical or mechanical systems or facilities, from designing those systems or facilities in accordance with applicable construction codes and standards for work to be performed and supervised by that contractor within the classification for which his or her license is issued, or from preparing electrical or mechanical shop or field drawings for work which he or she has contracted to perform. Nothing in this section is intended to imply that a licensed contractor may design work which is to be installed by another person

Envelope Mandatory Measures

The Mandatory Measures should be incorporated into the construction documents. The designer may use whatever format is most appropriate for specifying the mandatory measures in the plan set. In general, this will take the form of a note block near the front of the set, possibly with cross-references to other locations in the plans where measures are specified. A sample, generic envelope mandatory measures note block is shown in Example 3-6. This is offered as a starting point for designers; it should be incorporated into the organization of the plan set and modified to be specific to the building design.

Example 3-6: Sample Notes Block - Envelope Mandatory Measures

Nonresidential Energy Standards Compliance (Title 24, Part 6, Ch. 1)

Envelope Mandatory Measures

- **Installed Insulating Material** shall have been certified by the manufacturer to comply with the California Quality Standards for Insulating Material.
- **All Insulating Materials** shall be installed in compliance with the flame spread rating and smoke density requirements of Sections 2602 and 707 of the UBC.
- **All Exterior Joints** and openings in the building envelope that are observable sources of air leakage shall be caulked, gasketed, weather-stripped or otherwise sealed.
- **Site Constructed Doors, Windows and Skylights** shall be caulked between the unit and the building, and shall be weather-stripped (except for unframed glass doors and fire doors).
- **Manufactured Doors and Windows** installed shall have air infiltration rates certified by the manufacturer per Section 116(a)1. Manufactured fenestration products must be labeled for U-value according to NFRC procedures.
- **Demising Wall Insulation** (R-11) shall be installed in all opaque portions of framed walls (except doors).

B. ENV-1 Part 2

The information on Part 2 summarizes the information about the building envelope that can be readily verified by the building department field inspector. This form should be included on the plans. Alternatively, the information may be incorporated into construction assembly and glazing schedules on the plans, provided it is complete and in substantially the same format as this form.

Opaque Surfaces

1. **SURFACE TYPE** - provide a name or designator for each unique type of opaque surface. This designator should be used consistently throughout the plan set (elevations, finish schedules, etc.) to identify each surface. It should also be consistently used on the other forms in the compliance documentation.

2. **CONSTRUCTION TYPE** - list the general type of construction for each opaque surface type. The entry should be descriptive, as it is used by the field inspector to distinguish between the various assemblies.

3. AREA - list the gross surface area of the surface type.

4. U-VALUE - list the U-value of the surface type.

5. AZIMUTH - the plan Azimuth is determined by an observer standing outside the building looking at the front elevation.

6. TILT – Tilt of opaque surface is expressed in terms of degrees, 0=horizontal facing up, 90=vertical, 180=horizontal facing down.

7. SOLAR GAINS Y/N - indicate Y[es] for opaque surfaces that will be receive direct or indirect sunlight.

8. FORM 3 REFERENCE - list the name used on the ENV-3 form for the proposed assembly (whether or not it is a default value).

9. **LOCATION/COMMENTS** - use to provide further description for each surface type. Again, it should be descriptive to assist in locating and inspecting the assembly.

10. **NOTE TO FIELD** - this column is for building department use. It is intended as a communication mechanism between the plan checker and field inspector. The plan checker should note any critical or unusual details that are important to the building's energy compliance. There is additional space at the bottom of the form for more notes to the field inspector.

Fenestration Surfaces

1. **FENESTRATION TYPE** - provide a designator for each unique type of window.(e.g., window, skylight).

2. **AREA** - indicate the total square feet of all of the fenestration with the same characteristics.

3. **U-VALUE** - indicate the maximum U-value for windows using either manufacturer's data or the Energy Commission's default U-values (see Table 3-10).

4. **AZIMUTH** - the plan Azimuth is determined by an observer standing outside the building looking at the front elevation.

5. **SHGC** - list the solar heat gain coefficient (SHGC) of the fenestration product using either manufacturer's data or the Energy Commission's default SHGC values (see Table 3-11).

6. **GLAZING TYPE** - indicate the general type of primary glazing material for the window (clear, tinted, reflective, low-e, etc.).

7. **LOCATION/COMMENTS** - use to provide further description for each surface type. It should be descriptive enough to assist in locating and inspecting the fenestration.

8. **NOTE TO FIELD** - this column is for building department use. It is intended as a communication mechanism between the plan checker and field inspector. The plan checker should note any critical or unusual details that are important to the building's energy compliance. There is additional space at the bottom of the form for more notes to the field inspector.

Exterior Shading

1. Fenestration # - list the designation on the plans for the fenestration with exterior shading.

2. Exterior Shade Type - list the type of exterior shading, limited to devices permanently attached to the building (e.g., shade sceens), or structural components of the building (i.e., overhangs and fins). Manually operable shading devices cannot be modeled.

3. SC - list the shading coefficient of the shading device.

4. Window - when the shading type is an overhang or fin list the height and width (in feet) of the window.

5. Overhang - for overhangs being used to achieve compliance with prescriptive envelope requirements, list the dimensions (in feet) of the overhang:

   a. Length - is the distance (in feet) the overhang projects out from the building facade.

   b. Height - is the distance, in feet, from the bottom of the window to the bottom of the overhang. To qualify for credit, the bottom of the overhang must be no more than two vertical feet higher than the top of the window (window head).

c. LExt. and RExt. - is the length the overhang extends beyond the window on the left and right sides. Credit for an overhang may be taken only if the overhang extends beyond both sides of the window jamb a distance equal to the overhang length.

6. Left Fin – dimension which describe side fins to the left of the fenestration in feet-inches.

    a. Distance along the wall from the left edge of the glazing.

    b. Length of the left fin from the wall, from the length field in the fins.

    c. Height of the left fin from the bottom of the wall to the top of the fin.

7. Right Fin – dimension which describe side fins to the right of the fenestration in feet-inches.

    a. Distance along the wall from the right edge of the glazing.

    b. Length of the right fin from the wall, from the length field in the fins.

    c. Height of the right fin from the bottom of the wall to the top of the fin.

Notes to Field

This space is for building department use only. It may be used by the plan checker to continue or elaborate on notes elsewhere on the form.

C. Sample Form: ENV-1 Certificate of Compliance

CERTIFICATE OF COMPLIANCE (Part 1 of 2) ENV-1

PROJECT NAME		DATE
PROJECT ADDRESS		
PRINCIPAL DESIGNER-ENVELOPE	TELEPHONE	Building Permit #
DOCUMENTATION AUTHOR	TELEPHONE	Checked by/Date Enforcement Agency Use

GENERAL INFORMATION

DATE OF PLANS	BUILDING CONDITIONED FLOOR AREA	CLIMATE ZONE

BUILDING TYPE	☐ NONRESIDENTIAL	☐ HIGH RISE RESIDENTIAL		☐ HOTEL/MOTEL GUEST ROOM
PHASE OF CONSTRUCTION	☐ NEW CONSTRUCTION	☐ ADDITION	☐ ALTERATION	☐ UNCONDITIONED (file affidavit)
METHOD OF ENVELOPE COMPLIANCE	☐ COMPONENT	☐ OVERALL ENVELOPE		☐ PERFORMANCE

STATEMENT OF COMPLIANCE

This Certificate of compliance lists the building features and performance specifications need to comply with Title 24, Parts 1 and 6 of the California Code of Regulations. This certificate applies only to building envelope requirements.

The documentation preparer hereby certifies that the documentation is accurate and complete.

DOCUMENTATION AUTHOR	SIGNATURE	DATE

The Principal Envelope Designer hereby certifies that the proposed building design represented in this set of construction documents is consistent with the other compliance forms and worksheets, with the specifications, and with any other calculations submitted with this permit application. The proposed building has been designed to meet the envelope requirements contained in sections 110, 116 through 118, and 140, 142, 143 or 149 of Title 24, Part 6.

Please check one:

☐ I hereby affirm that I am eligible under the provisions of Division 3 of the Business and Professions Code to sign this document as the person responsible for its preparation; and that I am licensed in the State of California as a civil engineer or mechanical engineer, or I am a licensed architect.

☐ I affirm that I am eligible under the provisions of Division 3 of the Business and Professions Code by section 5537.2 or 6737.3 to sign this document as the person responsible for its preparation; and that I am a licensed contractor performing this work.

☐ I affirm that I am eligible under Division 3 of the Business and Professions Code to sign this document because it pertains to a structure or type of work described as exempt pursuant to Business and Professions Code Sections 5537, 5538 and 6737.1.

(These sections of the Business and Professions Code are printed in full in the Nonresidential Manual.)

PRINCIPAL ENVELOPE DESIGNER-NAME	SIGNATURE	DATE	LIC. #

ENVELOPE MANDATORY MEASURES

Indicate location on plans of Note Block for Mandatory Measures ____________________

INSTRUCTIONS TO APPLICANT

For Detailed instructions on the use of this and all Energy Efficiency Standards compliance forms, please refer to the Nonresidential Manual published by the California Energy Commission.

ENV-1: Required on plans for all submittals. Part 2 may be incorporated in schedules on plans.

ENV-2: Used for all submittals; choose appropriate version depending on method of envelope compliance.

ENV-3: Optional. Use if default U-values are not used. Choose appropriate version for assembly U-value to be calculated.

CERTIFICATE OF COMPLIANCE (Part 2 of 2) ENV-1

PROJECT NAME	DATE

OPAQUE SURFACES

Surface Type	Construction Type (e.g., Block, Wood, Metal)	Area	U-Value	Azimuth	Tilt	Solar Gains Y/N	Form 3 Reference	Location/Comments (e.g., Suspended Ceiling, Demising, etc.)	NOTES TO FIELD - For Building Dept. Use Only
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			
						☐ ☐			

FENESTRATION SURFACES

Fenestration Type	Area	U-Value	Azimuth	SHGC	Glazing Type	Location / Comments	NOTES TO FIELD - For Bldg. Dept. Use Only

EXTERIOR SHADING

Fenestration #	Exterior Shade Type	SHGC	Window		Overhang				Left Fin			Right Fin		
			Height	Width	Length	Height	LExt.	RExt.	Dist.	Length	Height	Dist.	Length	Height

NOTES TO FIELD - For Building Department Use Only

3.3.2 ENV-2: Envelope Component Method

This version of ENV-2 should be used only when the envelope is shown to comply using the Envelope Component Method.

1. **PROJECT NAME** is the title of the project, as shown on the plans, on the ENV-1, and known to the building department.

2. **DATE** is the date of preparation of the compliance submittal package. It should be on or after the date of the plans, and on or before the date of the building permit application.

A. Window Area Calculation

This calculation determines whether the window area for the building exceeds the allowable maximum for the Envelope Component Method.

1. **GROSS WALL AREA -** refer to Section 3.1.2A for definition and discussion. This is multiplied by 0.4 to determine the 40% area for glazing limits.

2. **DISPLAY PERIMETER** - refer to Section 3.1.2A for definition and discussion. This is multiplied by 6 to determine the display perimeter area for glazing limits.

3. **MAXIMUM ALLOWABLE WINDOW AREA** - the greater of the previous two calculation results is the maximum window area allowed under the Envelope Component Method.

4. **PROPOSED WINDOW AREA** - the total area of proposed windows shown on the plans is entered here. See Section 3.1.2A for definition and discussion. If this area is greater than the Maximum Allowable Window Area, then the Envelope Component Method may not be used.

B. Skylight Area Calculation

This calculation determines whether the skylight area for the building exceeds the allowable maximum for the Envelope Component Method.

1. **ATRIUM HEIGHT -** refer to Section 3.1.2A for definition and discussion.

2. **ALLOWED %** - Depending on the atrium height, the allowed percentage of roof area for skylights may be 5% (0.05) or 10% (0.1).

3. **GROSS ROOF AREA** - Gross roof area - refer to Section 3.1.2.A for definition and discussion.

4. **ALLOWABLE SKYLIGHT AREA** - Allowed Skylight Area - the maximum allowable skylight area is the product of the previous two numbers.

5. **ACTUAL SKYLIGHT AREA** - Actual Skylight Area - the total area of proposed skylights shown on the plans is entered here. See Section 3.1.2A for definition and discussion. If this area is greater than the Maximum Allowed Skylight Area, then the Envelope Component Method may not be used.

C. Opaque Surfaces

1. **ASSEMBLY NAME** - provide a name or designator for each unique type of opaque surface. This designator should be used consistently throughout the plan set (elevations, finish schedules, etc.) to identify each surface. It should also be consistently used on the other forms in the compliance documentation.

2. **TYPE** - provide the type of assembly as described in Tables 3-20 and 3-21 (e.g. wood-frame wall, other floor/soffit, etc.). If the proposed wood-framed wall, floor or ceiling assembly is one of the Standard Framed Wall/Floor/Ceiling Assembly types shown in Table B-7 of Appendix B, it is not necessary to

submit Form ENV-3 "Proposed Construction Assembly". Instead, provide the "Reference Name" from the appropriate assembly shown in Table B-7, e.g. R.30.2 x 10.16, in the "Opaque Surfaces" category.

3. **HEAT CAPACITY** - see Section 3.1.2G for discussion of how this value is found. For light weight assemblies having HC less than 7.0 (most framed assemblies), this space may be left blank. It may also be left blank for higher heat capacity assemblies, but if it is blank, the lower U-value requirements for walls and floors/soffits with HC of 7.0 or higher may not be used.

4. **INSULATION R-VALUE -** This section is used for assemblies that are shown to comply by this option under the Envelope Component Method. If the Assembly U-value option is used, this space may be left blank. The PROPOSED value is the R-value for the insulation product alone, not the total R-value for the assembly. It must be consistent with the R-value called out on the ENV-1 form. The MIN. ALLOWED value is taken from Tables 3-20 and 3-21.

5. **ASSEMBLY U-VALUE** - This section is used for assemblies that are shown to comply by this option under the Envelope Component Method. If the Insulation R-value option is used, this space may be left blank. The PROPOSED value is taken either from an Energy Commission table of defaults, or is calculated on the appropriate ENV-3 (see Appendix B, Sections 3.1.2C - F and Sections 3.3.4 - 3.3.6). If a default table value is used, check the “Y” (yes) box. If a calculated value is used, check the “N” (no) box and attach the corresponding ENV-3 form. The ALLOWED value is taken from Tables 3-20 and 3-21.

D. Windows

1. **WINDOW NAME** - provide a name or designator for each unique type of window. This designator should be used consistently throughout the plan set (elevations, window schedules, etc.) to identify each window. It should also be consistently used on the other forms in the compliance documentation.

2. **ORIENTATION -** indicate orientation (see Section 3.1.2A for definitions) of each unique type of window. A window with an overhang and a similar window without an overhang would be different types. If overhangs are not used, similar windows on non-north orientations may be grouped together.

3. **U-VALUE** - PROPOSED glazing U-value is determined as discussed in Section 3.1.2H. ALLOWED U-value is taken from Tables 3-20 and 3-21.

4. **NO. OF PANES** - indicate “2” for double glazed, “1” for single glazed windows.

5. **PROPOSED RSHG** – indicate SHGC (Solar Heat Gain Coefficient), OHF (Overhang Factor), and the resulting RSHG (RSHG = SHGCwin x $[1 + aH/V + b(H/V)^2]$). See Sections 3.1.2I and J. If given window does not have an overhang, then SHGC and RSHG are the same.

6. **ALLOW. RSHG** - the Maximum Relative Solar Heat Gain allowed, taken from Tables 3-20 and 3-21, depending on the window orientation (north or non-north).

E. Skylights

1. **SKYLIGHT NAME** - provide a name or designator for each unique type of skylight. This designator should be used consistently throughout the plan set (roof plans, skylight schedules, etc.) to identify each skylight. It should also be consistently used on the other forms in the compliance documentation.

2. **GLAZING** - Indicate if the glazing is transparent or translucent. This affects the allowed solar heat gain coefficient.

3. **NO. OF PANES** - indicate “2” for double glazed, “1” for single glazed skylights.

4. **U-VALUE** - PROPOSED glazing U-value is determined as discussed in Section 3.1.2H. ALLOWED U-value is taken from Tables 3-20 and 3-21.

5. **SOLAR HEAT GAIN COEFFICIENT** - indicate PROPOSED solar heat gain coefficient. See Section 3.1.2I. The ALLOWED value is the Maximum Solar Heat Gain Coefficient taken from Tables 3-20 and 3-21, depending on the type of glazing (transparent or translucent).

F. Sample Form: ENV-2 Envelope Component Method

ENVELOPE COMPONENT METHOD — ENV-2

PROJECT NAME	DATE

WINDOW AREA CALCULATION SKYLIGHT AREA CALCULATION

GROSS WALL AREA (GWA)		DISPLAY PERI-METER (DP)	
GWA x 0.40		DP x 6	

GREATER OF

	MAX. ALLOWABLE WINDOW AREA
	PROPOSED WINDOW AREA

If the PROPOSED WINDOW AREA is greater than the MAXIMUM ALLOWABLE WINDOW AREA, go to another method.

ATRIUM HEIGHT ____ FT

IF ≤ 55 FT — IF > 55 FT

		GROSS ROOF AREA		ALLOWED AREA
0.10	X		=	
0.05	X		=	

If the ACTUAL SKYLIGHT AREA is greater than the ALLOWED SKYLIGHT AREA, go to another method.

ACTUAL SKY. AREA ____

OPAQUE SURFACES

ASSEMBLY NAME (eg. Wall-1, Floor-1)	**TYPE** (eg. Roof, Wall, Floor)	**HEAT CAPACITY**	**INSULATION R-VALUE*** PROPOSED	**INSULATION R-VALUE*** MINIMUM ALLOWED	**ASSEMBLY U-VALUE*** PROPOSED	**ASSEMBLY U-VALUE*** TABLE VALUES? Y N	**ASSEMBLY U-VALUE*** MAXIMUM ALLOWED
						☐ ☐	
						☐ ☐	
						☐ ☐	
						☐ ☐	
						☐ ☐	

* For each assembly type, meet the minimum insulation R-value or the maximum assembly U-value.

WINDOWS

WINDOW NAME (e.g., Window-1, Window-2)	**ORIENTATION** N	E	S	W	**U-VALUE** PROP.	ALLOW.	**# OF PANES**	**PROPOSED RSHG** SHGC	H	V	H/V	OHF	PROP. RSHG	**ALLOWED** RSHG
	☐	☐	☐	☐										
	☐	☐	☐	☐										
	☐	☐	☐	☐										
	☐	☐	☐	☐										

SKYLIGHTS

SKYLIGHT NAME (e.g., Sky-1, Sky-2)	**GLAZING** TRANSLUCENT	TRANSPARENT	**# OF PANES**	**U-VALUE** PROPOSED	ALLOWED	**SOLAR HEAT GAIN COEFFICIENT** PROPOSED	ALLOWED
	☐	☐					
	☐	☐					
	☐	☐					
	☐	☐					

3.3.3 ENV-2: Overall Envelope Method

This version of ENV-2 should be used only when the envelope is shown to comply using the Overall Envelope Method.

1. **PROJECT NAME** is the title of the project, as shown on the plans, on the ENV-1, and known to the building department.

2. **DATE** is the date of preparation of the compliance submittal package. It should be on or after the date of the plans, and on or before the date of the building permit application.

A. ENV-2 Part 1 of 5

The first part of this form involves tests of glazing area for windows and skylights. If either of these tests does not pass, then the glazing area must be adjusted for the standard envelope.

Window Area Test

A. **DISPLAY PERIMETER** - refer to Section 3.1.2.A for definition and discussion. This is multiplied by 6 to determine the DISPLAY AREA for glazing limits.

B.-D. **GROSS EXTERIOR WALL AREA** - refer to Section 3.1.2A for definition and discussion. This is multiplied by 0.4 to determine the 40% area for glazing limits, and by 0.1 to determine the minimum area for glazing limits. The larger of the DISPLAY AREA and the 40% AREA is the MAXIMUM AREA.

E. **PROPOSED WINDOW AREA** - the total area of proposed windows shown on the plans is entered here. See Section 3.1.2A for definition and discussion.

If it is necessary to proceed to the following calculations, then the window area will be adjusted for the standard envelope. Otherwise, the window calculations on Parts 2 through 4 can be done without adjusted window or wall areas. Proceed to the SKYLIGHT AREA TEST.

1. or 2. **WINDOW ADJUSTMENT FACTOR** - depending on the values of E, D and C, one of these two calculations is done to obtain the WINDOW ADJUSTMENT FACTOR. This number is carried to Part 5 of the form to calculate the adjusted window and wall areas. Upon completion of those calculations, Parts 2 through 4 may be completed.

Skylight Area Test

This calculation determines whether the skylight area for the building exceeds the allowable maximum for the Standard Envelope.

1. **ATRIUM HEIGHT -** refer to Section 3.1.2.A for definition and discussion.

2. **STANDARD %** - depending on the atrium height, the allowed standard percentage of roof area for skylights may be 5% (0.05) or 10% (0.1).

3. **GROSS ROOF AREA** - gross roof area - refer to Section 3.1.2A for definition and discussion.

4. **STANDARD SKYLIGHT AREA** - the maximum allowed standard skylight area is the product of the previous two numbers.

5. **PROPOSED SKYLIGHT AREA** - the total area of proposed skylights shown on the plans is entered here. See Section 3.1.2A for definition and discussion.

If it is necessary to proceed to the following calculation, then the skylight area will be adjusted for the standard envelope. Otherwise, the skylight calculations on Part 2 and Part 3 can be done without the adjusted skylight or roof areas.

1. or 2. **SKYLIGHT ADJUSTMENT FACTOR** - this calculation is done to obtain the SKYLIGHT ADJUSTMENT FACTOR. This number is carried to Part 5 of the form to calculate the adjusted skylight and roof areas. Upon completion of those calculations, Parts 2 through 4 may be completed.

B. ENV-2 Part 2 of 5 Overall Heat Loss

This form should be used to confirm that the proposed envelope design has an overall heat loss no greater than the standard heat loss for the building.

A. **ASSEMBLY NAME** - provide a name or designator for each unique type of surface under the appropriate heading (WALLS, ROOFS/ CEILINGS, etc.). Demising walls are not to be included in this calculation. This designator should be used consistently throughout the plan set (elevations, finish schedules, etc.) to identify each surface. It should also be consistently used on the other forms in the compliance documentation. For windows and skylights, list the number of panes of glazing; indicate “2” for double glazed, “1” for single glazed windows.

B. **PROPOSED AREA** - enter the actual area, in square feet, of each assembly. Refer to Section 3.1.2.A for definitions and discussion.

C. **PROPOSED HEAT CAPACITY -** see Section 3.1.2.G for discussion of how this value is found. For light weight assemblies having HC less than 7.0 (most framed assemblies), this space may be left blank. It may also be left blank for higher heat capacity assemblies but if it is blank then the lower U-value requirements for walls and floors/soffits with HC of 7.0 or higher may not be used.

D. **PROPOSED U-VALUE** - enter the U-value of the proposed assembly as designed. U-values are taken either from an Energy Commission table of defaults, or are calculated on the appropriate ENV-3 (see Appendix B, Sections 3.1.2C - F and Sections 3.3.4 - 3.3.6).

   TABLE VALUES? - if the proposed wood-framed wall, floor or ceiling assembly is one of the Standard Framed Wall/Floor/Ceiling Assembly types shown in Table B-7 of Appendix B, it is not necessary to submit Form ENV-3 "Proposed Construction Assembly". Instead, provide the "Reference Name" from the appropriate assembly type shown in Table B-7, e.g. R.30.2 x 10.16, in the "Roofs/Ceilings" and "Floors/Soffits" categories under the "Assembly Name" column of Form ENV-2 Part 2 "Overall Envelope Method". Enter the "Assembly Name" as instructed in the form, followed by the "Reference Name".

E. **PROPOSED UA** - the numbers in columns B and D are multiplied together and the result entered in this column.

F. **STANDARD AREA -** if no window or skylight area adjustments are required (as demonstrated on Part 1), then the STANDARD AREA is the same as the PROPOSED AREA for each assembly. If adjustments are required, then the adjusted areas of window, wall, skylight and roof are taken from Part 5.

G. **STANDARD U-VALUE** - enter the Maximum U-value for each assembly type, taken from Tables 3-20 and 3-21. The selected value may depend upon the type of construction or the heat capacity of the assembly. These are determined in the same way as under the Envelope Component Approach, as described in Section 3.2.2.

H. **STANDARD UA** - the numbers in columns F and G are multiplied together and the result entered in this column.

Columns E and H are totaled and the results compared. If the Column E total is no greater than the Column H total, then the Overall Heat Loss requirement has been met.

C. ENV-2 Part 3 of 5 Overall Heat Gain from Conduction

This form should be used to confirm that the proposed envelope design has an overall heat gain from opaque surfaces no greater than the standard heat gain for the building.

A. **ASSEMBLY NAME** - provide a name or designator for each unique type of surface under the appropriate heading (WALLS, ROOFS/CEILINGS, etc.). Demising walls are not to be included in this calculation. This designator should be used consistently throughout the plan set (elevations, finish schedules, etc.) to identify each surface. It should also be consistently used on the other forms in the compliance documentation. For windows and skylights, list the number of panes of glazing; indicate “2” for double glazed, “1” for single glazed windows.

B. **PROPOSED AREA** - enter the actual area, in square feet, of each assembly. Refer to Section 3.1.2.A for definitions and discussion.

C. **TEMPERATURE FACTOR** - enter the temperature factor based on the envelope type and Climate Zone from Table 3-22 or *Standards* Table No. 1-J.

D. **PROPOSED HEAT CAPACITY -** see Section 3.1.2.G for discussion of how this value is found. For light weight assemblies having HC less than 7.0 (most framed assemblies), this space may be left blank. It may also be left blank for higher heat capacity assemblies but if it is blank then the lower U-value requirements for walls and floors/soffits with HC of 7.0 or higher may not be used.

E. **PROPOSED U-VALUE** - enter the U-value of the proposed assembly as designed. U-values are taken either from an Energy Commission table of defaults, or are calculated on the appropriate ENV-3 (see Appendix B, Sections 3.1.2C - F and Sections 3.3.4 - 3.3.6), or from EZ-FRAME output.

   TABLE VALUES? - if the proposed wood-framed wall, floor or ceiling assembly is one of the Standard Framed Wall/Floor/Ceiling Assembly types shown in Table B-7 of Appendix B, it is not necessary to submit Form ENV-3 "Proposed Construction Assembly". Instead, provide the "Reference Name" from the appropriate assembly type shown in Table B-7, e.g. R.30.2 x 10.16, in the "Roofs/Ceilings" and "Floors/Soffits" categories under the "Assembly Name" column of Form ENV-2 Part 2 "Overall Envelope Method". Enter the "Assembly Name" as instructed in the form, followed by the "Reference Name".

F. **HEAT GAIN Q** - the numbers in columns B, C and E are multiplied together and the result entered in this column.

G. **STANDARD AREA** - if no window or skylight area adjustments are required (as demonstrated on Part 1), then the STANDARD AREA is the same as the PROPOSED AREA for each window and skylight. If adjustments are required, then the adjusted areas are taken from Part 5.

H. **STANDARD U-VALUE** - enter the Maximum U-value for each assembly type, taken from Tables 3-20 and 3-21. The selected value may depend upon the type of construction or the heat capacity of the assembly. These are determined in the same way as under the Envelope Component Approach, as described in Section 3.2.2.

I. **TEMPERATURE FACTOR** - enter the temperature factor based on the envelope type and climate zone from Table 3-22 or *Standards* Table No. 1-J.

J. **HEAT GAIN Q** - the numbers in columns G, H and I are multiplied together and the result entered in this column.

Columns F and J are totaled and the results compared. If the Column F total is no greater than the Column J total, then the Overall Heat Gain requirement has been met.

D. ENV-2 Part 4 of 5 Overall Heat Gain from Radiation

This form should be used to confirm that the proposed envelope design has an overall heat gain no greater than the standard heat gain for the building.

A. **WINDOW/SKYLIGHT NAME** - provide a name or designator for each orientation of glazing under the appropriate heading (NORTH, SOUTH, SKYLIGHTS, etc.). This designator should be used consistently throughout the plan set (elevations, roof plans, etc.) to identify each surface. It should also be consistently used on the other forms in the compliance documentation.

B. **WEIGHTING FACTOR** - enter the weighting factor for each orientation and skylight. The weighting factors are taken from Table 3-23 or *Standards* Table No. 1-K, and depend on the climate zone (from ENV-1, Part 1).

C. **PROPOSED AREA** - the total area of proposed windows and skylights shown on the plans is entered here. See Section 3.1.2A for definitions and discussion.

D. **SOLAR FACTOR** - enter the solar factor for the applicable climate zone from Table 3-22 or *Standards* Table No. 1-J.

E. **PROPOSED SHGC** - the proposed solar heat gain coefficient of the glazing. See Section 3.1.2I.

F.-H. **PROPOSED OVERHANG** - indicate the overhang horizontal length (H), the overhang vertical height (V); overhang ratio (H/V); and overhang factor (OHF). Column F includes both (H for horizontal) and (V for vertical). See Section 3.1.2J. The overhang adjustment does not apply to skylights.

I. **PROPOSED TOTAL** - multiply columns B, C, D, E & H and enter the result here.

J. **STANDARD AREA** - if no window or skylight area adjustments are required (as demonstrated on Part 1), then the STANDARD AREA is the same as the PROPOSED AREA for each window and skylight. If adjustments are required, then the adjusted areas are taken from Part 5.

K. **STANDARD RSHG** - this is the Maximum Relative Solar Heat Gain taken from Tables 3-20 and 3-21 depending on the window orientation (north or non-north). The Maximum Solar Heat Gain Coefficient for skylights is taken from the same table, depending on whether the skylight glazing is transparent or translucent.

L. **SOLAR FACTOR** - enter the solar factor for the applicable climate zone from Table 3-22 or *Standards* Table No. 1-J.

M. **STANDARD TOTAL -** multiply columns B, J, K & L and enter the result here.

Columns I and M are totaled, Totals from Columns F and J from Part 3 of 5 are carried forward and added, and the results compared. If the Column I total is no greater than the Column M total, then the Overall Heat Gain requirement has been met.

E. ENV-2 Part 5 of 5 Window Area Adjustment Calculations

This form should be included with all compliance submittals. If the WINDOW AREA TEST or the SKYLIGHT AREA TEST (Part 1 of this form) determines that area adjustments are not necessary, check the NOT APPLICABLE boxes. If the tests indicate that adjustments must be made, perform the calculations in the appropriate sections below.

A. **WALL NAME** - provide a name or designator for each unique type and orientation of wall that contains windows (walls without windows will have no adjustment). If an orientation has two different wall types, list each separately. This designator should be used consistently throughout the plan set (elevations, finish schedules, etc.) to identify each surface. It should also be consistently used on the other forms in the compliance documentation. See Section 3.1.2A for a discussion of orientation.

B.-D. **AREAS** - list the areas (in square feet). See Section 3.1.2.A for definitions of these areas. The GROSS AREA is the Gross Exterior Wall Area for the particular wall type and orientation under consideration. The DOOR AREA and WINDOW AREA are for doors and windows included in each wall.

E. **WINDOW ADJUSTMENT FACTOR** is calculated on the top half of Part 1. It is the same for all windows in the building.

F. **ADJUSTED WINDOW AREA** is calculated by multiplying the values in Columns D and E.

G. **ADJUSTED WALL AREA** is calculated by subtracting B from the sum of C and F. If this produces a negative value enter zero.

Add Columns B, C, D, F and G. As a check, the total of Column B should equal the sum of the totals of Columns F & G.

The total in Column G is used in Column F of the Overall Heat Loss calculation (Part 2) and Column I of the Overall Heat Gain from Conduction calculation (Part 3) and the values in Column F are used in Column G of the Overall Heat Gain from Radiation calculation (Part 4).

Skylight Area Adjustment Calculations

A. **ROOF NAME** - provide a name or designator for each unique type of roof that contains skylights (roofs without skylights will have no adjustment). If an orientation has two different roof types, list each separately. This designator should be used consistently throughout the plan set (roof plans, skylight schedules, etc.) to identify each surface. It should also be consistently used on the other forms in the compliance documentation.

B.-C. **AREAS** - list the areas (in square feet). See Section 3.1.2A for definitions of these areas. The GROSS AREA is the Gross Exterior Roof Area for the particular roof type and orientation under consideration; note that it does not include doors, such as roof hatches. The SKYLIGHT AREA is for skylights included in each roof.

D. **SKYLIGHT ADJUSTMENT FACTOR** is the Skylight Adjustment Factor calculated on the bottom half of Part 1. It is the same for all skylights in the building.

E. **ADJUSTED SKYLIGHT AREA** is calculated by multiplying the values in columns C and D.

F. **ADJUSTED ROOF AREA** is calculated by subtracting E from B. If this results in a negative value enter zero.

Columns B, C, E and F are added. As a check, the total of Column B should equal the sum of the totals of Columns E and F.

The totals in Columns E and F are used in Column F of the Overall Heat Loss calculation (Part 2) and in Column G of the Overall Heat Gain from Conduction calculation (Part 3), and the values in Column E are used in Column I of the Overall Heat Gain from Radiation calculation (Part 4).

F. Sample Form: ENV-2 Overall Envelope Method

OVERALL ENVELOPE METHOD (Part 1 of 5) ENV-2

PROJECT NAME	DATE

WINDOW AREA TEST

A. DISPLAY PERIMETER		FT × 6 =		SF DISPLAY AREA
B. GROSS EXTERIOR WALL AREA		SF × 0.40 =		SF 40% AREA
C. GROSS EXTERIOR WALL AREA		SF × 0.10 =		SF MINIMUM STANDARD AREA
D. ENTER LARGER OF A OR B				SF MAXIMUM STANDARD AREA
E. ENTER PROPOSED WINDOW AREA				SF PROPOSED AREA

IF E IS GREATER THAN D OR LESS THAN C, PROCEED TO THE NEXT CALCULATION FOR WINDOW AREA ADJUSTMENT. IF NOT, GO TO PART 2 OF 5.

1. IF E IS GREATER THAN D:

MAXIMUM STANDARD AREA		PROPOSED WINDOW AREA		WINDOW ADJUSTMENT FACTOR
	÷		=	

GO TO PART 5 TO CALCULATE ADJUSTED AREA

2. IF LESS THAN C:

MAXIMUM STANDARD AREA		PROPOSED WINDOW AREA (IF E = 0 ENTER 1)		WINDOW ADJUSTMENT FACTOR
	÷		=	

GO TO PART 5 TO CALCULATE ADJUSTED AREA

SKYLIGHT AREA TEST

ATRIUM HEIGHT ______ FT

OR

IF ≤ 55 FT → 0.05; **IF > 55 FT** → 0.10

STANDARD %		GROSS ROOF AREA		STANDARD SKYLIGHT AREA
0.10	x		=	
0.05	x		=	

PROPOSED SKYLIGHT AREA ______

IF THE PROPOSED SKYLIGHT AREA IS GREATER THAN THE STANDARD SKYLIGHT AREA, PROCEED TO THE NEXT CALCULATION FOR THE SKYLIGHT AREA ADJUSTMENT. IF NOT, GO TO PART 2 OF 5.

1. IF PROPOSED SKYLIGHT AREA ≥ STANDARD SKYLIGHT AREA:

STANDARD SKYLIGHT AREA		PROPOSED SKYLIGHT AREA (IF E = 0 ENTER 1)		SKYLIGHT ADJUSTMENT FACTOR
	÷		=	

GO TO PART 5 TO CALCULATE ADJUSTED AREAS

OVERALL ENVELOPE METHOD (Part 2 of 5) ENV-2

PROJECT NAME	DATE

OVERALL HEAT LOSS

	A		B	C	D			E	F	G	H
			PROPOSED						STANDARD		
	ASSEMBLY NAME (e.g. Wall-1, Floor-1)		AREA	HEAT CAPACITY	U-VALUE	TABLE VALUES? **Y**	**N**	UA (B × D)	**AREA*** (Adjusted)	U-VALUE	**UA** (F × G)
WALLS						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
ROOFS/CEILINGS						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
FLOORS/SOFFITS						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
						☐	☐				
WINDOWS		# OF PANES		N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				
SKYLIGHTS		# OF PANES		N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				
				N/A		☐	☐				

* If Window and/or Skylight Area Adjustment is Required, use adjusted areas from part 5 of 5.

TOTAL ← Column E shall be no greater than column H → TOTAL

OVERALL ENVELOPE METHOD (Part 3 of 5) ENV-2

PROJECT NAME	DATE

OVERALL HEAT GAIN FROM CONDUCTION

	A		B	C	D	E			F	G	H	I	J
			PROPOSED							STANDARD			
	ASSEMBLY NAME (e.g. Wall-1, Floor-1)	# OF PANES	AREA	TEMP. FACTOR	HEAT CAPACITY	U-VALUE	TABLE VALUES? Y	N	HEAT GAIN (B ×C ×E)	AREA* (Adjusted)	U-VALUE	TEMP. FACTOR	HEAT GAIN (G ×H ×I)
WALLS							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
ROOFS/CEILINGS							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
FLOORS/SOFFITS							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
							☐	☐					
WINDOWS					N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
SKYLIGHTS					N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
					N/A		☐	☐					
									SUBTOTAL				SUBTOTAL

* If Window and/or Skylight Area Adjustment is Required, use adjusted areas from part 5 of 5.

OVERALL ENVELOPE METHOD (Part 4 of 5) ENV-2

PROJECT NAME	DATE

OVERALL HEAT GAIN FROM RADIATION

	A	B	C	D	E	F		G	H	I	J	K	L	M
			PROPOSED								STANDARD			
	WINDOW/SKYLIGHT NAME (e.g Window-1, Sky-1)	WEIGHTING FACTOR	AREA	SOLAR FACTOR	SHGC	OVERHANG H	OVERHANG V	H/V	OHF	HEAT GAIN (BxCxDxExH)	AREA (Adjusted)*	RSHG or SHGC**	SOLAR FACTOR	HEAT GAIN (B×J×K×L)
NORTH														
EAST														
SOUTH														
WEST														
SKYLIGHTS						N/A	N/A	N/A	N/A					
						N/A	N/A	N/A	N/A					
						N/A	N/A	N/A	N/A					
						N/A	N/A	N/A	N/A					
						N/A	N/A	N/A	N/A					

Proposed		Standard	
Part 4 Subtotal		Part 4 Subtotal	
Part 3 Subtotal		Part 3 Subtotal	
TOTAL		TOTAL	

* If Window and/or Skylight Area Adjustment is Required, use adjusted areas from part 5 of 5.

** Only SHGC is used for Skylights

Column **I** must be less than column **M**

OVERALL ENVELOPE METHOD (Part 5 of 5) ENV-2

PROJECT NAME	DATE

WINDOW AREA ADJUSTMENT CALCULATIONS

☐ CHECK IF NOT APPLICABLE (see Part 1 of 5)

A					B	C	D	E	F	G
WALL NAME (e.g. Wall-1, Wall-2)	**ORIENTATION** N	E	S	W	**GROSS AREA**	**DOOR AREA**	**WINDOW AREA**	**WINDOW ADJUSTMENT FACTOR** (From Part 1)	**ADJUSTED WINDOW AREA** (D×E)	**ADJUSTED WALL AREA** B-(F+C)
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
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	☐	☐	☐	☐						
	☐	☐	☐	☐						
	☐	☐	☐	☐						
TOTALS:										

SKYLIGHT AREA ADJUSTMENT CALCULATIONS

☐ CHECK IF NOT APPLICABLE (see Part 1 of 5)

A	B	C	D	E	F
ROOF NAME (e.g. Roof-1, Roof-2)	**GROSS AREA**	**SKYLIGHT AREA**	**SKYLIGHT ADJUSTMENT FACTOR** (From Part 1)	**ADJUSTED SKYLIGHT AREA** (C×D)	**ADJUSTED ROOF AREA** (B - E)
TOTALS:					

3.3.4 ENV-3: Proposed Metal Framed Assembly

For most metal framed assemblies, the U-value will be found in Table B-2 in Appendix B (see Section 3.1.2E for a discussion of the use of this table). When there is no appropriate U-value in Table B-2, then this version of ENV-3 should be used to calculate the assembly U-value.

[Note that this form is not used to describe metal furring systems for insulating masonry or concrete walls; these are described in ENV-3 Masonry Assemblies.]

1. **PROJECT NAME** is the title of the project, as shown on the plans and known to the building department.

2. **DATE** is the date of preparation of the compliance submittal package. It should be on or after the date of the plans, and on or before the date of the building permit application.

A. Component Description

1. **SKETCH OF ASSEMBLY** - provide a simple cross-section sketch showing the arrangement of components in the assembly. The position of framing members and layers should be apparent. Number the layers in sequence from outside to inside as they will be described below (framing members are not numbered, only the cavity layers are considered here). Note that the outside of the assembly, facing unconditioned space, is at the left.
2. **ASSEMBLY NAME** - list the name or designator for this assembly as it is referred to on the plans and on the other compliance forms in the submittal, e.g. WALL-1, ROOF-2, or some other naming convention appropriate to the construction document organization.
3. **ASSEMBLY TYPE** - check the appropriate box.
4. **FRAMING MATERIAL** - must be metal for this form (other versions of ENV-3 are for other framing materials).
5. **FRAMING SIZE** - enter the nominal dimensions of the framing members, e.g. 3 1/2", 5 1/2", or other appropriate description.
6. **INSULATION R-VALUE** - enter the R-value of the insulation material in the assembly. If there is more than one insulation material, list each separately.

B. Construction Components

In this part of the form, the R-value of the cavity (the area of the wall that does not contain framing members) is calculated.

1. **DESCRIPTION** - list each layer of the assembly in sequence, from outside to inside, as numbered in the sketch above.

2. **CAVITY R-VALUE (R_c) -** enter the R-value of each layer. This value is taken from manufacturers' literature or from the *ASHRAE Handbook of Fundamentals Volume, 1993,* Chapter 22, Table 4, *Typical Thermal Properties of Common Building and Insulating Materials.* The R-values for the INSIDE and OUTSIDE SURFACE AIR FILMS are taken from Table 3-1, Standard Air Film R-values.

3. **METAL FRAMING FACTOR (MFF)** - enter the appropriate value for the assembly from Table 3-5 (Appendix B, Table B-3), or the table on the form.

4. **Rc X MFF** - multiply the SUBTOTAL R-value (R_c) for the cavity by the METAL FRAMING FACTOR and enter the result.

5. **INSULATING SHEATHING -** if there is a layer of insulating sheathing (other than the cavity insulation between the framing members), enter its R-value. Only values from *ASHRAE Handbook of Fundamentals Volume, 1993,* Table 3a, Chapter 23, may be used.

6. **TOTAL R-VALUE (R_t)** - add the previous two numbers and enter the result here.

7. **ASSEMBLY U-VALUE** - divide 1 by the TOTAL R-VALUE (R_t) to obtain the ASSEMBLY U-VALUE.

COMMENTS may be added to further explain the assembly or its U-value calculation. This would be especially helpful for unusual assemblies, and could help to expedite plan checking for energy compliance.

C. Sample Form: ENV-3 Proposed Metal Framed Assembly

PROPOSED METAL FRAMED ASSEMBLY — ENV-3

PROJECT NAME	DATE

COMPONENT DESCRIPTION

OUTSIDE — INSIDE

SKETCH OF ASSEMBLY

ASSEMBLY NAME		
ASSEMBLY TYPE	☐	Floor
	☐	Wall
	☐	Ceiling/Roof
FRAMING MATERIAL		
FRAMING SIZE		
FRAMING SPACING	16” o. c.☐	24” o. c.☐
INSULATION R-VALUE		

CONSTRUCTION COMPONENTS

	DESCRIPTION	CAVITY R-VALUE (Rc)
	OUTSIDE SURFACE AIR FILM	
1		
2		
3		
4		
5		
6		
7		
	INSIDE SURFACE AIR FILM	

SUBTOTAL		Rt
METAL FRAMING FACTOR		MFF
Rt × MFF		R-VALUE
INSULATING SHEATHING		R-VALUE
TOTAL R-VALUE		Rt
1/Rt		ASSEMBLY U-VALUE

METAL FRAMING FACTOR			
Stud Spacing	Stud Depth	Insulation R-Value	Non-Mass Wall
16 o. c.	4”	R-7	0.522
		R-11	0.403
		R-13	0.362
		R-15	0.328
	6”	R-19	0.325
		R-21	0.300
		R-22	0.287
		R-25	0.263
24 o. c.	4”	R-7	0.577
		R-11	0.458
		R-13	0.415
		R-15	0.379
	6”	R-19	0.375
		R-21	0.348
		R-22	0.335
		R-25	0.308

COMMENTS

3.3.5 ENV-3: Proposed Masonry Wall Assembly

This version of ENV-3 should be used for masonry wall assemblies (including concrete block, brick and solid concrete). It is used in conjunction with Tables B-4 and B-5 in Appendix B, which give U-values and heat capacities for most common assemblies. It should also be used to account for the insulating qualities of insulating sheathing and/or furred sheathing layers attached to the masonry. Refer to Section 3.1.2F for further description of these calculations.

1. **PROJECT NAME** is the title of the project, as shown on the plans, on the ENV-1, and as known to the building department.

2. **DATE** is the date of preparation of the compliance submittal package. It should be on or after the date of the plans, and on or before the date of the building permit application.

A. Component Description

1. **SKETCH OF ASSEMBLY** - provide a simple cross-section sketch showing the arrangement of components in the assembly. The position of any furring members and sheathing layers should be apparent. Note that the outside of the assembly, facing unconditioned space, is at the left.

2. **WALL ASSEMBLY NAME** - list the name or designator for this wall assembly as it is referred to on the plans and on the other compliance forms in the submittal, e.g. WALL-1, or some other naming convention appropriate to the construction document organization.

3. **DESCRIPTION OF ASSEMBLY** - provide a brief description of the materials used in the assembly to augment the sketch.

B. Wall R-value and Heat Capacity

This section is used to extract values of wall R-value and heat capacity from Tables B-4 or B-5 in Appendix B.

1. **WALL UNIT THICKNESS** - enter the nominal thickness, in inches, of the masonry wall.

2. **MATERIAL TYPE** - enter the material type. For concrete block, this can be “light weight”, “medium weight”, or “normal weight” as per ASTM designations.

3. **CORE TREATMENT** - this is only applicable to hollow core masonry units; the choices are solid grouted cores, or partially grouted cores with the unfilled cells either empty or filled with any type of insulation.

4. **WALL R-VALUE (R_w)** - for hollow masonry, use Table B-4; for solid unit masonry or solid concrete walls, use Table B-5. Select the appropriate R-value and enter it here (see Section 3.1.2F for more discussion).

5. **WALL HEAT CAPACITY (HC)** - for hollow masonry, use Table B-5; for solid unit masonry or solid concrete walls, use Table B-5. Select the appropriate HC value and enter it here (see Section 3.1.2G for more discussion).

C. Furring/Insulation Layer

This section is used to describe any furring/insulation layers or insulating sheathing attached to either the inside or the outside of the masonry.

1. **FURRING FRAMING MATERIAL** - list the type of material (wood, metal) used for the furring strips; if not applicable enter "none".

2. **FURRING FRAMING SIZE** - enter the thickness, width, and depth, in actual inches, of the framing members used for furring, and its actual dimensions in inches.

3. **FURRING SPACE INSULATION** - enter the type of insulation installed in the space between furring strips (fiberglass batt, bead board, etc.), and its R-value at the installed thickness.

4. **EXTERIOR INSULATING LAYER** - if there is an exterior insulating layer, list the type of insulation (bead board, polyisocyanurate board, etc.), and its R-value at the installed thickness.

5. **FURRING ASSEMBLY EFFECTIVE R-VALUE** - using the information above, enter Table B-6 and locate the effective R-value of the furring assembly (see Section 3.1.2F).

6. **INSULATION LAYER R-VALUE (R_f)** - add the FURRING ASSEMBLY EFFECTIVE R-VALUE to the R-value of the exterior insulating layer to arrive at the INSULATION LAYER R-VALUE (R_f).

D. Wall Assembly R-value and U-value

1. **WALL ASSEMBLY R-VALUE (R_t)** - add the INSULATION LAYER R-VALUE calculated above (R_t) to the WALL R-VALUE (R_w) from above to obtain the WALL ASSEMBLY R-VALUE.

2. **WALL ASSEMBLY U-VALUE** - calculate the inverse of the WALL ASSEMBLY R-VALUE ($1/R_t$) to obtain the WALL ASSEMBLY U-VALUE.

E. Sample Form: ENV-3 Proposed Masonry Wall Assembly

PROPOSED MASONRY WALL ASSEMBLY — ENV-3

PROJECT NAME	DATE

COMPONENT DESCRIPTION

OUTSIDE

INSIDE

SKETCH OF ASSEMBLY

ASSEMBLY NAME

DESCRIPTION OF ASSEMBLY

WALL R-VALUE and HEAT CAPACITY

WALL UNIT THICKNESS		NOMINAL INCHES
MATERIAL TYPE		(LW CMU,MW CMU, NW CMU, CLAY UNIT, CLAY BRICK, CONCRETE.)
CORE TREATMENT		(SOLID, GROUTED, EMPTY, INSULATED, NA)
WALL R-VALUE		Rw (FROM TABLE B-4 or B-5)
WALL HEAT CAPACITY		HC (FROM TABLE B-4 or B-5)

FURRING/INSULATION LAYER (INSIDE and/or OUTSIDE IF ANY)

FURRING FRAMING MATERIAL		(WOOD, METAL, NONE)		
FURRING FRAMING SIZE		NOMINAL INCHES		ACTUAL INCHES
FURRING SPACE INSULATION		TYPE		R-VALUE
EXTERIOR INSULATING AREA		TYPE		R-VALUE

FURRING ASSEMBLY EFFECTIVE R-VALUE		**EXTERIOR INSULATING LAYER R-VALUE**		**INSULATION LAYER R-VALUE**	
	+		=		Rf
(FROM TABLE B-7)		(FROM MANUFACTURER)			

WALL ASSEMBLY R-VALUE and U-VALUE

INSULATION LAYER R-VALUE		**WALL R-VALUE**		**WALL ASSEMBLY R-VALUE**		**WALL ASSEMBLY U-VALUE**
	+		=		➜	
Rf		**Rw**		**Rt**		**1/Rt**

3.3.6 ENV-3: Proposed Wood Frame Assembly

This version of ENV-3 should be used for any construction assembly that is not found in the tables in Appendix B or appropriate for the metal framed or masonry versions of ENV-3. This form guides the user through the basic U-value calculation, the Parallel Path Method (discussed in Section 3.1.2D), and the heat capacity calculation (see Section 3.1.2G). If the proposed wood-framed wall, floor or ceiling assembly is one of the Standard Framed Wall/Floor/Ceiling Assembly types shown in Table B-7 of Appendix B, it is not necessary to submit Form ENV-3 "Proposed Construction Assembly". Instead, the "Reference Name" for the appropriate assembly is entered into either Form ENV-2 "Envelope Component Method" or ENV-2 Part 2 "Overall Envelope Method", whichever is applicable for the compliance method that the designer has selected. Refer to the specific sections in the Manual which provide instructions for filling out the respective forms, as to how the Reference Name of the assembly should be entered.

1. **PROJECT NAME** is the title of the project, as shown on the plans, on the ENV-1, and as known to the building department.

2. **DATE** is the date of preparation of the compliance submittal package. It should be on or after the date of the plans, and on or before the date of the building permit application.

A. Component Description

1. **SKETCH OF ASSEMBLY** - provide a simple cross-section sketch showing the arrangement of components in the assembly. The position of framing members and layers should be apparent. Number the layers in sequence from outside to inside as they will be described below (framing members are not numbered, only the cavity layers are considered here). Note the outside of the assembly, facing unconditioned space, is at the left of the sketch.

2. **ASSEMBLY NAME** - list the name or designator for this assembly as it is referred to on the plans and on the other compliance forms in the submittal, e.g. WALL-1, ROOF-2, or some other naming convention appropriate to the construction document organization.

3. **ASSEMBLY TYPE** - check the appropriate box.

4. **FRAMING MATERIAL** - with this form framing material is wood only (other versions of ENV-3 are for other materials).

5. **FRAMING SIZE** - enter the nominal dimensions of the framing members, e.g. 2x4, 4x8, or other appropriate description.

6. **FRAMING PERCENTAGE** - choose the appropriate value from the small table to the right. For example, a floor assembly with joists spaced 24" on center (o.c.) would have a framing percentage of 7%.

B. Construction Components

In this part of the form, the R-value of the cavity (the area of the assembly that does not contain framing members) and the R-value of the assembly through the wood framing are calculated. The U-value of the assembly is also calculated.

1. **DESCRIPTION** - list each layer of the assembly in sequence, from outside to inside, as numbered in the sketch above.

2. **CAVITY R-VALUE (R_c) -** enter the R-value of each layer at a cross-section taken through the cavity. This value is taken from manufacturer's literature or from *the ASHRAE Handbook of Fundamentals Volume, 1993,*

(Chapter 22, Table 4, *Typical Thermal Properties of Common Building and Insulating Materials*) data reproduced in Appendix B, Table B-1. The R-values for the INSIDE and OUTSIDE SURFACE AIR FILMS are taken from Table 3-1, Standard Air Film R-values.

3. **WOOD FRAME R-VALUE (R_f)** - enter the R-value of each layer at a cross-section taken through a framing member. These values are found in the same sources cited in the previous paragraph.

4. **HEAT CAPACITY (HC) -** As an option, the HC of the assembly may also be calculated, although for most framed assemblies the HC will be too low to be of significance (HC values of less than 7 are not given any special consideration under the *Standards*).

5. **WALL WEIGHT -** enter the weight of each layer of the assembly, per square foot of the material at its given thickness. This is calculated from the density of the material, which is given in pounds per cubic foot. See Table 3-9 for typical values; they may also be taken from manufacturers literature or other standard reference works, such as the *ASHRAE Handbook of Fundamentals Volume, 1993*, Chapter 22 Table 4 (Appendix B). Dividing the density by 12 and multiplying by the material thickness (in inches) yields the WALL WEIGHT. For the framing material, the weight of the framing members must be converted to a pounds per square foot value.

6. **SPECIFIC HEAT** - enter the specific heat of each material, in Btu/°F-lb. These values are also found in ASHRAE Table 4 (see previous paragraph).

7. **HC** - columns A and B are multiplied together to obtain the heat capacity for each layer of the assembly.

8. **SUBTOTALS** - both R-value columns are summed. If calculated, the HC column is also summed to obtain the TOTAL HC for the assembly.

9. **ASSEMBLY U-VALUE** - the appropriate values from above on this form are entered into the equation and the result calculated. Rc is the subtotal of the CAVITY R-VALUE column; R_f is the subtotal of the WOOD FRAME R-VALUE column. Fr% is the FRAMING PERCENTAGE. Care should be taken to recognize the parentheses in the calculation.

C. Sample Form: ENV-3 Wood Frame Assembly

PROPOSED WOOD FRAME ASSEMBLY ENV-3

PROJECT NAME	DATE

COMPONENT DESCRIPTION

OUTSIDE

INSIDE

SKETCH OF ASSEMBLY

ASSEMBLY NAME

ASSEMBLY TYPE (check one)
- **Floor**
- **Wall**
- **Ceiling/Roof**

FRAMING MATERIAL

FRAMING SIZE Fr %: ______________

FRAMING PERCENTAGE

15% (16” o. c. Wall
12% (24” o. c. Wall)
10% (16” o. c. Floor/Ceil.)
7% (24” o. c. Floor/Ceil.)

CONSTRUCTION COMPONENTS

	DESCRIPTION	R-VALUE: CAVITY R-VALUE (Rc)	R-VALUE: WOOD FRAME R-VALUE	HEAT CAPACITY (optional): A WALL WEIGHT lbs/sf	HEAT CAPACITY (optional): B SPECIFIC HEAT (Btu/F°•lbs)	HEAT CAPACITY (optional): HC (A×B) (Btu/F°•sf)
	OUTSIDE SURFACE AIR FILM					
1						
2						
3						
4						
5						
6						
7						
	INSIDE SURFACE AIR FILM					
	SUBTOTAL	Rc	Rf		TOTAL HC	

[______ x ______] + [______ x ______] = ______

1/Rc | 1 - (Fr%/100) | 1/Rf | Fr%/100 | ASSEMBLY U-VALUE

COMMENTS

3.4 ENVELOPE INSPECTION

The envelope building inspection process for energy compliance is carried out along with the other building inspections performed by the building department. The inspector relies upon the plans and upon the ENV-1 Certificate of Compliance, or a similar form, that must be printed on the plans (see Section 3.3.1). Included on the ENV-1 are “Notes to Field” which are provided by the plan checker to alert the inspector to items of special interest for field verification.

To assist in the inspection process, an Inspection Checklist is provided in Appendix I.

Chapter 3 Index

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